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HOW SPONGES ARE GATHERED AND ARTIFICIALLY GROWN.

By NEWTON FOREST.

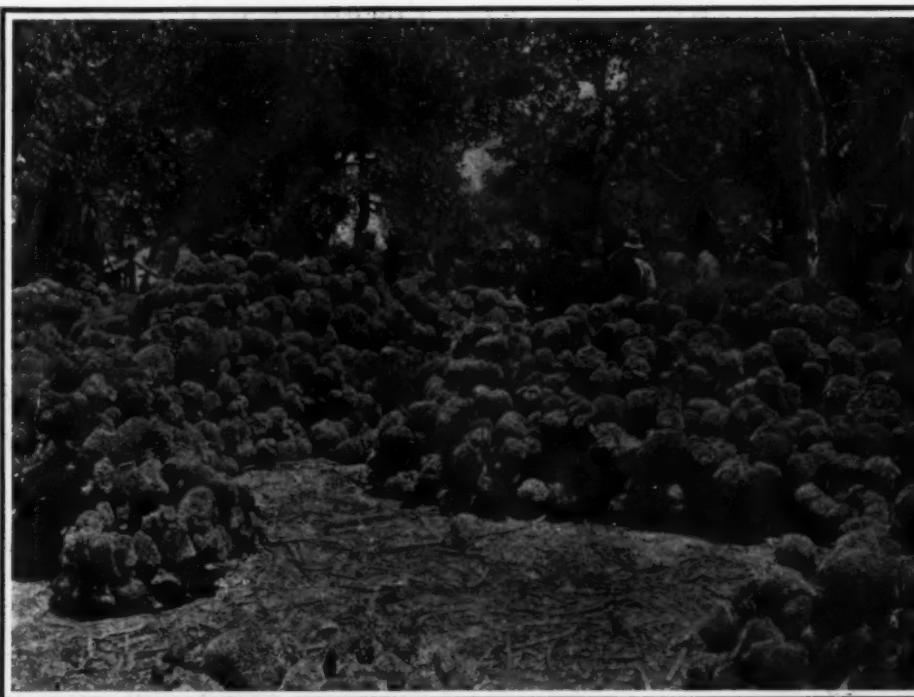
WHERE do all the sponges come from? We see them every day, and while everyone knows that they are products of the sea, few know how they are gathered and how limited are the fishing districts where they are caught. The sponge industry of the United States dates back half a century or more, when the people of Key West, with that little island as a base, began

fishing in adjacent waters. Gradually, as the sponges became scarce, operations were extended up the Gulf coast.

The two places where sponge fishing can now best be studied are Tarpon Springs, on the west coast of Florida, and Batabano, on the south coast of Cuba. Though these points are what might be called within a stone's throw of each other, the modes of gathering the sponges are so entirely different that they might be half a world apart. In Florida the industry is pursued with all the ceremony and science that money and

modern ingenuity can employ, while on the coast of Cuba the business is conducted with all the primitiveness and leisure associated with sponge fishing since classic times. The Cuban goes out in what is called a *chalupa*, a craft that might be described as a cross between a flat-bottom river boat and a canoe. He takes with him his professional instruments, which consist of three poles ten, thirty, and fifty feet in length (the ends of each being fitted with a three pronged harpoon) and a "deep-sea" spyglass.

(Continued on page 408.)



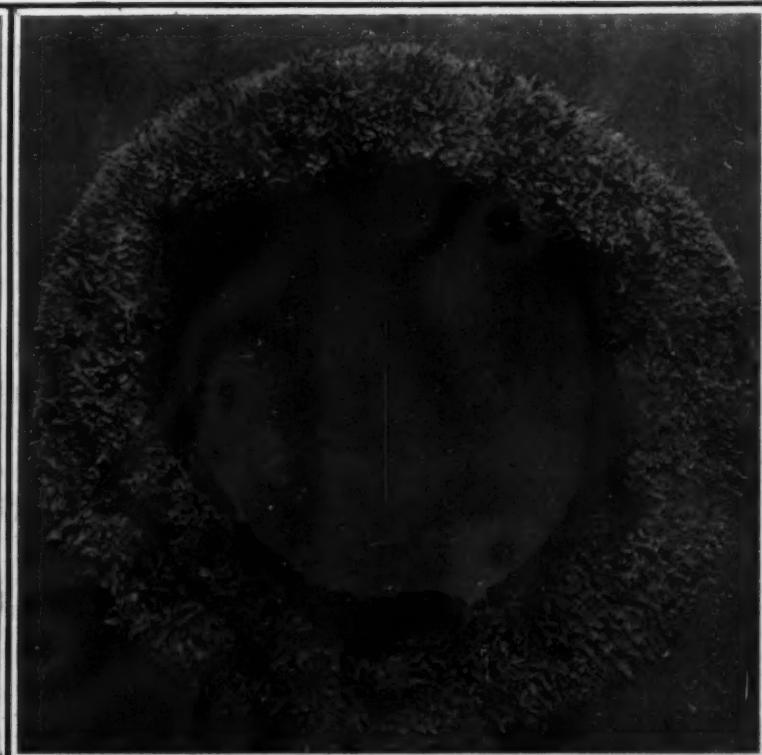
TYPICAL SPONGE MARKET WHERE SPONGES ARE SOLD TO THE HIGHEST BIDDER.



THE GREEK DIVER IS FAST EXTERMINATING THE SPONGE.



THE NEW ARTIFICIALLY PRODUCED ROOTLESS SPONGE.



AN ODDLY-SHAPED GRASS SPONGE.

HOW SPONGES ARE GATHERED AND GROWN.

GASOLINE AND ALCOHOL ENGINES.

COMMERCIAL DEDUCTIONS FROM COMPARISON TESTS.

BY ROBERT M. STRONG.

Continued from Supplement No. 1772, page 387.

OTHER FACTORS AFFECTING FUEL CONSUMPTION.

SPEED of Engine.—The speed, or a combination of piston speed and revolutions per minute, will affect the fuel economy and thermal efficiency, and for a limited range, at least, increased speed will decrease the fuel consumption and increase the thermal efficiency, nearly alike for both fuels if the best operating conditions are obtained for both. This is likely to hold true up to the limiting practical combination of piston speed and revolutions per minute, which is governed by mechanical conditions, but the tests from which the above inference was drawn covered only a range of speeds of 200 to 290 revolutions per minute, with corresponding average piston speeds of 500 to 750 feet per minute.

Series of tests with gasoline and with alcohol, consisting of 16 and 27 tests, respectively, were made on the same engine (15-horse-power Otto gasoline engine) with the same compression. These tests were required to determine the best load, fuel needle-valve setting, and time of ignition, for each of the speeds mentioned and an intermediate one. With speeds of 200 to 300 revolutions per minute, the rate of fuel consumption, in pounds per brake horse-power per hour, varied with increasing speed from 0.68 to 0.64 for gasoline (a decrease of 6 per cent) and from 1.11 to 1.05 for alcohol (a decrease of 5.5 per cent). A change in the speed of the engine is likely to change many conditions affecting the rate of fuel consumption, such as throttling from too-high air velocity through the carburetor, air passageways, and valves, as well as by affecting the mixture quality and best time of ignition. Hence it is very difficult to eliminate all the independent variables and determine the exact effect of change in speed alone. The detailed report of these tests may, however, assist in so extending this phase of the investigation as to determine the most advantageous limits of the possible combinations of speed and cylinder dimensions.

Size of Engine.—Similarly, the size of the engine—that is, of the engine cylinder—has a certain influence on the fuel economy and thermal efficiency. A large cylinder engine can be operated with a higher efficiency than a small one, probably because of the difference in heat loss due to the lesser ratio of cooling surface to volume of charge or heat liberated. But the difference from this cause, which has been fairly well determined by experiment, is negligible for the difference in the size of the engines used for this work. It is small as compared with the difference caused by mechanical conditions, such as leakage and friction, which are likely to be much greater in proportion for a small engine than for a large one. For similar reasons it is also harder to maintain compression with a small engine than with a large one, and this difficulty increases with the degree of compression. Hence a small alcohol engine is likely to be less satisfactory than a small gasoline engine, this depending entirely, however, on the perfection of construction and the skill of the operator.

Carburation.—The construction of carburetors and induction passageways suitable to the economical use of gasoline and alcohol are details of engine design, and the conditions governing carburation are, to a great extent, pre-determined. In most cases but little is left for the operator to adjust aside from the quantity of the fuel or the quality and quantity of air and fuel mixture.

The principle of the ordinary carburetor is that of the simple atomizer, and any effective atomizing device will make a good carburetor if the other influencing conditions are properly taken care of. Since alcohol is less volatile than gasoline, and hence harder to vaporize, a higher velocity of air through the carburetor and a greater excess of fuel are required to obtain an explosive mixture on starting an engine with alcohol than with gasoline. This high air velocity may be obtained by giving the engine a higher rotative speed (which will also tend to assist the vaporization of the spray carried by the air, by giving less time for the dissipation of the heat of compression to the cylinder walls), or by throttling the carburetor in such a way as further to increase the velocity of the air at the spray nozzle and reduce the pressure at which vaporization takes place. With a combination of these conditions it is not difficult to start a small alcohol engine "cold." To start a large alcohol engine, however, which cannot readily be revolved rapidly by hand, some mechanical means of bringing it

up to speed will be required, or if the engine is not too large this may be accomplished by priming with gasoline and starting in the usual manner. Hot passageways and cylinder walls assist in vaporizing the fuel at the start, at least, but are not necessary if the previously mentioned conditions are maintained.

Under similar operating conditions with equal air velocities more alcohol than gasoline will pass into the cylinder of the engine in the form of a spray, but unless too great an excess of fuel is used it is probably completely vaporized by the heat from the cylinder walls and hot gases left in the clearance space from the preceding explosion or by the heat developed during compression. With the ordinary piston speeds used in stationary engine practice, a velocity of the air through the carburetor at the spray nozzle sufficiently high to produce as effective vaporization or atomization of alcohol as of gasoline can be obtained without throttling the engine to any appreciable degree.

Throttling.—Some very interesting and instructive information on the effect of throttling as an operating condition has been obtained. It appears that for any given compression the more the charge is diluted the better will be the fuel economy and thermal efficiency of the engine, if the smallest quantity of fuel possible per charge and the best time of ignition are used. The details of the tests that show, and possibly explain, this condition of affairs are too many and complicated to take up at this time; but it is evident that if the rule is true equal volumetric efficiency of the pump action (suction and compression strokes) is one of the conditions that must be imposed on comparative tests with gasoline and alcohol, when used either in the same or in different engines. Irregularities of pump action can be eliminated only by obtaining the maximum possible compression, and consequently the minimum possible amount of throttling for the engines used. The entire amount of throttling is not, however, always under the control of the operator, for it depends on the conditions under which the engine is running, the size of the passageways and valves, and the timing of the valves.

Valve Timing.—The effect of the timing of the exhaust valve is comparatively small and for any reasonably well-designed and adjusted engine can be neglected. The timing of the inlet valve, however, is of considerable importance. If an automatic inlet valve is used, the spring tension and the distance the valve opens will determine the timing and the amount the charge is throttled in passing the valve. The best spring tension and lift for automatic valves differ under different conditions, and no general rule for adjustment can be given. The best adjustment can usually be determined by trial, if the best combination of the spring tension and lift is that with which the engine will carry the greatest load, when the needle-valve and igniter settings are adjusted accordingly. If the engine is equipped with an indicator so that light spring diagrams of the suction and the beginning of the compression stroke can be taken, the best combination of spring tension and valve lift can readily be determined by so adjusting them that the maximum volumetric efficiency of the pump stroke is obtained, as shown by the point at which the compression line crosses the atmospheric line.

When the inlet valve is mechanically operated, its maximum lift is pre-determined by the design; but where a considerable lost motion is provided for, the lift and timing of the valve can usually be changed considerably. In some engines the timing can also be changed by shifting the gears that drive the two-to-one shaft. In general, the timing of a mechanically-operated inlet valve should be such that it does not completely close until about 20 deg. to 30 deg. after the piston has passed the dead center at the beginning of the compression stroke. No set rule, however, can be given, and the same methods should be employed as in determining the best spring tension and lift of the automatic valve. Light spring diagrams illustrating the application of this method of determining the best valve settings have been prepared for the final report.

The throttling effect of restricted induction passageways may often be greatly reduced by proper timing of the inlet valve. The air passageway through carburetors, however, is often so small as to throttle the charge beyond the possibility of recovery by timing of the inlet valve. This is not necessary and should be avoided.

Jacket Temperature.—A question asked by almost every operator is: "What effect has the temperature of the jacket or cooling water on the fuel economy and thermal efficiency of an alcohol or gasoline engine, and what is the best jacket temperature?" The only safe answer to this question is: "The best jacket temperature is that which gives the best results." Many tests tend to show that the temperature of the cooling water has little if any appreciable effect, by controlling to a greater or less extent the temperature of the cylinder walls, on the fuel economy and thermal efficiency of the engine. Jacket temperature may, however, have a great effect on the performance of the engine from its influence on other conditions than cylinder-wall temperature. It has been pretty well established that when jacket temperature affects the fuel consumption of an alcohol or gasoline engine it is more by effect on cylinder lubrication, fit of piston and valves, and carburation than by change in heat loss to the cylinder walls. A hot jacket may stop leakage by way of the piston and valves by making them tight from expansion, or it may make a tight piston stick and bind and warp valves or valve seats that are tight when the cylinder walls are kept cold. If the cylinder oil used is thick and heavy, it will flow better when the cylinder is kept hot, but thin oil is more likely to run out and leave the piston dry. If the design of the carburetor is such that efficient carburation and uniform mixtures depend on hot passageways, a hot jacket will help counteract the effect of such poor or limited design; and the ultimate effect of a hot jacket on the fuel consumption is, for this reason, likely to be greater for alcohol than for gasoline.

The temperature to which the jacket water can be raised is limited in some engines by a design such that for a high temperature of jacket water the cooling system is not effective in keeping all the parts below the temperature that will cause preignition. It is not necessary to keep the temperature of the jacket water high if the design and construction of the engine is right to begin with and suitable cylinder oil is used. A "hot jacket" may, however, be a good remedy for many ills that result from poor or limited design and construction.

When a constant load is applied to a gasoline or alcohol engine and the governor action is reasonably steady, or the disturbing effect of the governor is constant, a change in temperature of the jacket water, if it causes any increase or decrease of mechanical or thermal efficiency, will so change the action of the governor as to compensate for the more or less economical use of the fuel. This change in the action of the governor alters its disturbing effect on the quality or the uniformity of the mixture, and the operating conditions are almost hopelessly altered so far as determining the isolated effect of change in jacket temperature is concerned. The ultimate effect of the change in jacket temperature may, however, be determined if the best combination of fuel needle-valve settings and time of ignition is used in each case and if the load is above about 50 per cent of the maximum the engine will carry, so that the disturbing effect of the governor action will be automatically reduced to a minimum.

If the hit-or-miss method of governing is used, the minimum action of the governor—that is, the minimum practical number of cut-outs per minute—will be the same, regardless of the effect of jacket temperature on the efficiency of carburation.

If the throttle method of governing is used, however, the efficiency of carburation may be affected by the position of the governor-controlled throttle valve; that is, by the amount of throttling and consequent change in the suction and the compression pressures, so that the best combination of fuel needle-valve settings and time of ignition may be different for different jacket temperatures and may complicate the effect on the rate of fuel consumption through a change in both mixture quality and compression. This is true for both gasoline and alcohol, but where the jacket temperature affects the efficiency of carburation, the resultant effect on the rate of fuel consumption will be greater for alcohol than for gasoline.

The results of the tests that were made with different jacket temperatures for each of the engines used for this work indicate that the effect of jacket temperature on the efficiency of carburation of gasoline and of alcohol can be eliminated in both cases by proper care in designing the carburetor and induction passageways. These experiments consisted of eight series

of tests, three with gasoline and five with alcohol. First, the minimum gasoline consumption rate at best load for the 15-horse-power Otto gasoline engine (hit-or-miss method of governing) was determined when a low jacket temperature (about 80 deg. F. at the outlet) was used, and the effect of raising the temperature of the jacket water to the boiling point (212 deg. F. at the outlet) was noted. There was no apparent change in the action of the governor to indicate any change in the efficiency with which the fuel was being used, but to make certain the consumption rate was determined for nine different outlet jacket-water temperatures between 80 deg. and 212 deg. F. The results of these tests show that whatever change there may have been in the temperature of the cylinder walls, as measured by the outlet temperature of the jacket water for a range of over 100 deg. F., the change in the rate of fuel consumption was slight—a decrease of less than 0.01 pound of fuel per brake horse-power per hour, or 1.7 per cent. A similar series of nine tests was made for alcohol, with identical results.

These tests were carried a little further with the second 15-horse-power Otto gasoline engine, and the engine settings were systematically sought that would give the best results for each of five different outlet temperatures of the jacket water. Two series of tests were made, 49 with gasoline and 19 with alcohol, but with the same ultimate effect as before. After the compression pressure of this engine had been raised to about 85 pounds per square inch above atmosphere, another systematic series of search tests, 12 in all, was made with alcohol to determine the minimum fuel consumption for four different jacket temperatures (as measured by the outlet temperature of the jacket water) from 80 deg. to 212 deg. F., but the amount of decrease in the rate of fuel consumption was the same as that previously noted. Similar experiments on the 10-horse-power Nash gasoline engine (hit-or-miss method of governing), consisting of 5 tests with gasoline and 9 with alcohol, gave the same results, though the details of the method of governing and carburetor construction were different.

The 15-horse-power Otto alcohol engine, which was equipped with a still different carburetor, and on which the throttle method of governing was used, could not be operated satisfactorily with alcohol when the outlet temperature of the jacket water was below 100 deg. F., except under a partially throttled condition, with a corresponding increase in the rate of fuel consumption. For outlet temperatures of the jacket water between 100 deg. and 200 deg. F., the best fuel needle-valve setting and corresponding best time of ignition were coincident with the minimum amount of throttling and corresponding maximum compression. There was but little gain in fuel economy—about 0.01 pound per brake horse-power per hour.

Though the results of these tests are almost entirely negative, they were necessary for establishing the best operating conditions; and the tables which give all the data that were taken in them are of vital importance to the study of the whys and wherefores. These tables will appear in the final report.

Preheating the Air.—Preheated air may be of great benefit when the carburation is ineffective, or the mixture not uniform in quality; but preheating the air is not necessary to obtain the best results with alcohol, and if carried to any great degree will materially diminish the capacity of the engine and decrease the maximum practical degree of compression.

Preheating the air to 250 deg. F. reduced the maximum horse-power of the engine about 15 per cent for alcohol and about 14 per cent for gasoline. With an air temperature of 75 deg. to 85 deg. F., the temperature of the gasoline vapor or spray and air mixture, taken as it entered the cylinder through the inlet valve housing, was from 80 deg. to 100 deg. F. It was usually approximately the same as the air temperature. When the air was preheated to 450 deg. F., the mixture temperature was raised only to 172 deg. F.

With an air temperature of 72 deg. F., the temperature of the air and alcohol mixture at the inlet valve was found to be 61 deg. F. This mixture temperature was increased only to 96 deg. F. when the air was preheated to 250 deg. F., and the condition of minimum fuel consumption for maximum load was maintained in both cases, as for the tests with gasoline.

By plotting the minimum fuel-consumption rates in pounds of fuel per brake horse-power per hour, and the brake load in per cent of maximum brake horse-power for the normal and preheated-air temperature tests, the results show a slight increase in the fuel-consumption rate with increased air temperature. An increase of about 0.05 pound per brake horse-power per hour, alike for gasoline and alcohol and the same for all loads, was obtained for air preheated to 250 deg. F.

With air preheated to approximately 250 deg. F., a series of 48 tests with alcohol was made on the 15-horse-power Otto gasoline engine, as required to determine the minimum rate of alcohol consumption for each of 4 different loads from maximum load to about one-third load, so that comparison could be made with results previously determined by a series of tests for 4 different loads when the air was not preheated. A

similar experiment with gasoline consisted of 35 tests on the same 15-horse-power Otto engine for maximum load and half load when the air was preheated. A previously taken set of tests for 7 loads from maximum load to one-third load when the air was not preheated was used for comparison.

Twenty-seven additional tests with gasoline and 48 with alcohol were made in order to determine the minimum fuel consumption and mixture temperatures corresponding to intermediate temperatures of the preheated air for various loads. No beneficial effect could be obtained directly or indirectly by the use of preheated air. It should be stated, however, that in the engine used for these tests the passageway between the carburetor and inlet valve was very short, and the mixture temperatures given are the temperatures of the air mixed with atomized and partially vaporized fuel as it passed into the cylinder.

Size and Intensity of Ignition Spark.—Misfiring from ineffective ignition is, of course, detrimental to the fuel economy of an engine for either fuel alike, but the ordinary ignition appliances are apparently as effective for igniting alcohol mixtures as gasoline mixtures. No attempt was made to obtain information as to the comparative efficiency of different methods of ignition, but the question was gone into far enough to demonstrate that under operating conditions approximately best for gasoline, increasing the size or intensity of the spark (as measured by the voltage and current supplied to a make-and-break igniter) from 4.5 watts (4.5 volts and 1 ampere, the amount necessary to ignite every charge) to 48 watts (19 volts and 4.4 amperes) had no effect on the thermal efficiency or fuel economy of the engine. The details of these tests, four in all, will be given in the final report for reference if further study is desired.

In view of the fact that this is a much-disputed point, it should be said that if the method of ignition used is the jump spark in the high-tension secondary circuit of an induction coil, there will be a certain amount of building up in the coils and lag of the vibrator, causing the spark to lag. This lag may or may not be appreciable, but if changing the current or the voltage of the igniter circuit affects this lag to any appreciable degree its effect on the fuel economy and thermal efficiency will be that of changing the time of ignition, and will coincide with any effect produced by change in the intensity and size of spark; or it may account for the entire change which is apparently due to the change in the intensity and size of spark. If the mechanically-operated low-tension make-and-break method of ignition is used, as was the case in the experiments referred to, there will be no building-up effect or lag, as the spark occurs after the circuit has been closed for some little time, and is not affected by change in voltage or current.

Degree of Compression.—As previously stated, the minimum fuel-consumption rates and maximum thermal efficiencies for gasoline and alcohol were obtained with the maximum degree of compression that could be used for each. Furthermore, when alcohol was used, it was found that the maximum thermal efficiencies obtained, for six different degrees of compression, each

fulfilled the equation $E = 1 - \left(\frac{P_a}{P_b}\right)^{10}$; where E equals

the thermal efficiency, calculated from the indicated horse-power and lower heating value of the fuel, P_a equals atmospheric pressure in pounds per square inch absolute, and P_b equals the pressure at the end of compression stroke in pounds per square inch absolute.

Each of the above degrees of compression was the maximum for the respective clearance ratio of the engine used; they ranged from 70 to 200 pounds per square inch above atmosphere (85 to 215 pounds absolute). The maximum thermal efficiency values referred to above range from 28 per cent to 40 per cent for the range of compression pressures given, and were obtained from a preceding series of tests made to determine the variation of best fuel economy and maximum thermal efficiency with load. These series of tests were made on different engines with different clearance ratios and corresponding degrees of compression, as follows: Four series of tests on four engines, each with a different clearance ratio; three series of tests on the same engine with three different clearance ratios; and two series of tests on two different engines with the same clearance ratio.

Similarly, when gasoline was used, the best thermal efficiencies obtained for compressions of 70 pounds per square inch above atmosphere (85 pounds absolute) and 92 pounds per square inch above atmosphere (107 pounds absolute) fulfill the equation

$E = 1 - \left(\frac{P_a}{P_b}\right)^{10}$. These results were obtained from a

series of tests on two gasoline engines having the same clearance ratio and compression pressure, and a third engine having a smaller clearance ratio and a correspondingly higher compression pressure.

The above equations are similar to the theoretical equation for thermal efficiency when expressed in terms of pressure from the air card, or standard reference

diagram, and differ only in the numerical value of the exponent. The exponent for the theoretical air card, or standard reference diagram efficiency, is 0.29.

It must be clearly understood, however, that the thermal efficiencies obtained for the different clearance ratios and corresponding degrees of compression fulfilled the equations only when the maximum thermal efficiency of the engine was obtained, which required that the engines be put in the best possible running condition and operated to the best advantage. This required that the best combination of time of ignition and fuel needle-valve setting for the best load be obtained. When the engines were in the best possible running condition, and were operated for minimum fuel consumption, the best load was coincident with the minimum disturbing effect of the method of governing and the maximum compression pressure for the clearance ratio of the engine. This latter condition is of vital importance for the comparison of thermal efficiency for different compressions; for if, for any reason at all, the engines are operated under different conditions with respect to throttling of the charge, the maximum thermal efficiencies obtainable will not fulfill the same equation. The extent of the effect of throttling on the maximum thermal efficiency obtainable for any corresponding compression pressure will be seen from the following illustration: When alcohol was used in an engine whose clearance ratio was such that the maximum compression pressure, with the minimum throttling (94 per cent of piston displacement), was 70 pounds per square inch above atmosphere (85 pounds absolute), a maximum thermal efficiency of 28 per cent was obtained. Similarly, a maximum thermal efficiency of 35.8 per cent was obtained for an engine whose clearance ratio was such that the maximum compression pressure, with minimum throttling (approximately the same as given above), was 140 pounds per square inch above atmosphere (155 pounds absolute). Both of these values fulfill the

equation $E = 1 - \left(\frac{P_a}{P_b}\right)^{10}$. But when the latter engine was throttled to such an extent that the compression pressure was reduced to 70 pounds per square inch above atmosphere (85 pounds absolute) the maximum thermal efficiency for the correspondingly reduced load was 35 per cent, or an increase of 7 in percentage over the value obtained for the engine whose maximum compression was 70 pounds per square inch above atmosphere, and does not fulfill the equation given above. The horse-power of the engine was, of course, greatly reduced (to approximately one-third maximum load). Maximum thermal efficiencies for intermediate conditions of throttling and corresponding compression pressures gave similar results, and the same was found to hold true for other engines.

No attempt to explain these results or to discuss their significance will be made at this time, as the details of the tests are necessary for a clear understanding of the deductions.

(To be continued.)

PROGRESS ON THE GATUN LOCKS.

BETWEEN August 24th, when the work of laying concrete in Gatun Locks with the permanent plant was begun, and the close of work on September 18th, 7,066 cubic yards of concrete had been laid. The amount placed is increasing with the increase in the efficiency of the handling and mixing plants. The best record up to September 18th was made on that day, when 638 cubic yards were laid. Concrete is being laid at present in the 20-foot floor of the forebay, in the center of the upper lock chamber, and in the floor of the east chamber of the upper lock. Of the lateral culverts, with the floor wells, 160 feet have been built, and the forms have been pulled without difficulty.

All three units in the power-house are in working condition. The changes in the automatic electric cars, which carry materials to the mixer, are continuing. Although the chief change made is merely to reinforce the I-beam on which the motors are mounted, in order to do away with the wobbling of the motors, it involves taking the car apart and the work therefore will probably take two weeks or more. The dozen cars that have already been changed are giving satisfactory service. In the cableway plant the electrically controlled air brake by which the speed of hoisting and lowering the buckets is regulated is being changed to hand control.

Wooden forms for the connections between the lateral culverts and the main culverts are being made at the wood shop at Gatun. These forms will be in the shape of an elbow, elliptical at the end which connects with the lateral culverts and circular at the top where the connection with the balance valves of the main tunnels is made. The diameters of the ellipse will be 8 feet and 6 1/2 feet, respectively, the form will be 25 feet long, and will weigh between 7,000 and 8,000 pounds. In each pair of locks there will be 25 of these connections between the lateral culverts and the tunnel in the center wall, and 25 between the lateral culverts and the tunnels in the side walls, and 150 forms will therefore be required.—Canal Record.

PRESENT-DAY AERODYNAMIC RESEARCHES.

RATEAU'S INTERESTING EXPERIMENTS.

BY PAUL MINET.

For some time past, aviation has been predominant in all minds. The flights of Wilbur Wright have awakened the fondest hopes on aeroplaning, and Blériot's exploit of crossing the English Channel opens up the most brilliant future to the new industry of transportation through the air.

It is absolutely certain that the first experiments by the most skilled aviators have been made at random, without the help of any established rules, and

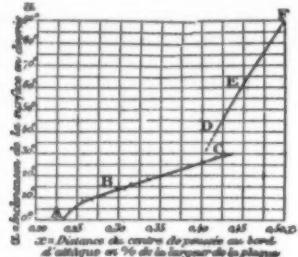


Fig. 1.—Position of Center of Air Pressure on a Plane Surface.

that is not the least glorious share of the bold and trusting pilots who have ventured to try flying machines that were far from perfect.

Thus it is now known that flying is the easiest thing. But in truth every experiment is made with each successive machine as if no previous study had taken place, and one begins again as at the inception of the automobile, when everything was left to chance.

Nevertheless, it is to be hoped that the fundamental principles of the mechanical properties of fluids will be made known as early as possible, as also the coefficients needed in practice, in order to make a perfectly accurate flying machine.

To that end, numerous experiments are absolutely necessary. Naturally, the present trials made with aeroplanes may furnish some indications, but the phenomena sought may also be hidden and the deductions drawn from them prove entirely erroneous.

What is wanted is methodical experiments, every one made according to an invariable principle, and after having ascertained the accuracy of such principle. These experiments will be made in the laboratory, with all due precautions to ensure the exactness of the figures, and by this means certain bases will be obtained that will greatly help the development of aviation.

M. A. Rateau, the eminent engineer, and well known by his remarkable labors on turbines, has recently put into practice a trial method initiated by himself last year. Thanks to the co-operation of the Société d'études de locomotion aérienne (Society for the study of aerial locomotion), he has been able to set up a trial apparatus, which is beginning to show results. These are most interesting.

M. Rateau's understanding of the experiments to be made is as follows: He places the surfaces to be tried upon (planes, objects of whatever shape, propellers) in a very homogeneous air current. The ob-

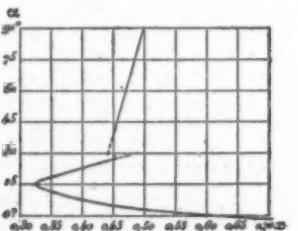


Fig. 2.—Position of Center of Air Pressure on an Incurved Surface.

ject being stationary, it is easy to take all the measurements required and to repeat the operation as often as desired.

The current is supplied by a fan, and the air comes out through a large converging nozzle, and strikes horizontally the object under consideration. It will be noticed that by this arrangement, the air is not obstructed on the sides as is the case with tunnel systems. Here the air escapes laterally and entirely freely and this point may be of considerable importance in determining the exactness of the figures.

The fan employed is one especially examined by M. Rateau. It is helicoidal in shape and has a diameter of 1.20 meters (47 inches). It is belt driven by a

gasoline motor of 25 horse-power. We have thus a considerable power available, which permits of great changes in the speed of the air current.

This fan carries the air into a tight chamber measuring 1.60 meters (63 inches) side. Within this chamber a partition and a wooden lattice have been conveniently set, to avoid back-draft, and to insure the air currents to come out perfectly parallel to one another.

The starting velocity of the air is constantly measured by an ordinary Pitot tube, attached to a water gage. The velocities are shown with the greatest precision from zero up to a speed of 40 meters (43% yards) per second, equal to 144 kilometers (89½ miles) per hour.

Facing the nozzle there is a wooden vertical frame made as light as possible so that its inertia may not have to be taken into account. The weight of this frame is otherwise balanced at the top by means of two sheet-iron plungers, immersed in two special cisterns.

Toward the center of the height of the frame there are two sheet-iron plates provided with pincers that catch and hold in place the surface to be tried. Special screws enable the surface to be dipped at will and a reading shows the exact inclination.

It is known that a surface struck by an air current receives a certain push that may be divided in two

assuming that the relative velocities are exactly equal.

The principles of mechanics are against any inequality whatever. It is necessary to investigate whether the experiments that have produced different results do not show some flaws not discovered hitherto. The forces at play depend only on the relative velocities and the results must be identical.

Besides, M. Rateau is to undertake a series of experiments that will entirely clear up this point. In any

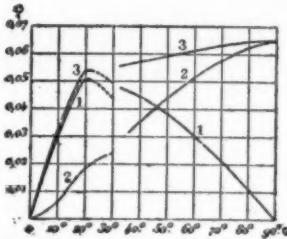


Fig. 3.—Vertical and Horizontal Components of the Pressure and the Total Pressure for a Plane Surface.

event, the comparison that can be made between the first results obtained during the experiments and the figures determined by M. Eiffel in his own trials at the 300 meter (328 yards) tower, justifies the fullest confidence in the experimental method that we have just described.

In the experiments made, attention was first given to the investigation of the push center, regarding which only the most vague data are available. Two different methods were employed, so that one may check the other.

The first method consisted in disposing the tried plate in such a manner that it could turn round a straight line forming a transverse axis to the air current. The plate was let loose while the fan was running. The plate then took a certain dip subject to the position of the axis.

Thus the position of the center of gravity for this dip was immediately ascertained, since it is necessarily on the axis. It has been proved that the equilibrium was stable, except for certain dips in the case of curved surfaces. The method was not, therefore, general.

In the second method, the rotating axis of the plate was disposed on its front edge, and the plate was loaded with certain weights. Under the action of the air current, it made dips subject to the velocity of the air current, the weight of the plate and the extra load.

This method makes it necessary first to determine the preliminary impulsions in order to arrive at the total pressure, from which the position of the push center can be deduced. The equilibrium was then always stable. The results obtained agreed also with the conclusions reached by the first method.

We give an illustration embodying the results obtained with a plate measuring 500 millimeters (19.685 inches) perpendicularly to the direction of the wind and 300 millimeters (11.811 inches) in the direction of the wind. The plate was 1 1/4 millimeters (0.0492125



VIEW OF RATEAU APPARATUS.

Showing the frame and the floats, and at one side the scale for measuring the horizontal thrust.

components, one vertical, which tends to raise the surface, the other horizontal, which tends to carry the surface away. The point is so to arrange the apparatus as to quickly measure the value of these two components for each dip of the plate and for each velocity.

The raising component is easily ascertained. In fact, at the bottom of the frame there are two scales on which the weights are arranged so as to bring it back to its normal position. These weights immediately show the component sought.

The horizontal component seems more difficult to measure. It is determined by attaching the frame to two wooden arms symmetrically placed to right and left, half way up. These arms, under the action of the air push, carry another two vertical arms, moving round an axis, and supporting a lever on whose extremity the weights can be put.

It is in fact a pair of scales, one of whose trays, namely, the frame, moves horizontally. An intermediate back gearing is arranged so that the force exerted on this tray is vertically transmitted to another tray on which weights are to be placed.

The experiment is not as simple as might be thought, because it is necessary, at each new incidence, to make the push center on the surface coincide with the center of the frame. Preliminary experiments gave for each dip the position of the push center, and once the surface was properly adjusted, the reading of the results showed promptly.

It is pertinent to inquire whether the results are exactly identical when the surface moves in the air and when it is stationary and the air moves instead,

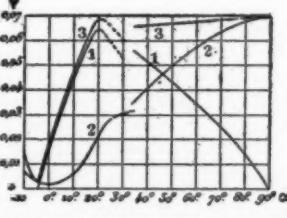


Fig. 4.—Vertical and Horizontal Components of Pressure and the Total Pressure for an Incurved Surface.

inches) thick and the borders were beveled to a feather-edge.

The curve's abscissa shows the ratio of the distance from the push center to the anterior edge of the plate's width. It is obvious that the curve is composed of two parts absolutely distinct, contrary to what was formerly believed regarding the continuity of the positions of the push center.

When the dips incline toward zero, the push center advances up to 0.236 on the width. As the dip increases the center moves back in a regular manner, slowly at first, then more rapidly, till about 26 deg. It appears that in these slight dips, the rule governing

the flow of the liquid currents acts regularly in the same direction.

From 36 deg. up, the push center moves away much less quickly but steadily. The rule governing the air currents is evidently no longer the same. In fact, in great dips or inclinations the air currents next to the edge of the plate suffer a certain setback and tend to escape off the plate's border.

Between 26 deg. and 29 deg., two positions of the push center at which there is equilibrium have been recorded. The two rules governing the flow are possible and easily transformed into one another.

Between 29 deg. and 36 deg., there is no possible angle of equilibrium. During this interval, no condition of stable equilibrium is attained, whatever kind of plate is submitted to experiment.

Let us point out that the experiments were made at velocities reaching up to 30 meters (98.4 feet) per second, without any perceptible variation in the position of the push center at the different dips considered.

Equally interesting results have been obtained with a curved plate of cylindrical shape having the same dimensions as the preceding. The profile of this plate is formed by an arc of a circle whose tangent at the end makes an angle of 10 deg. with the chord.

Our illustration No. 2 shows the results obtained by arranging the plate so that the air strikes its concave face. The angle is the one formed by the chord with the direction of the air.

Above 15 deg. the curves present the same disposition as in the plane surface; 30 deg. is the unstable position. Below 15 deg. the push center goes back rapidly and passes from the valve 0.325 to the valve 0.60 for a void angle.

M. Rateau's experiments were then directed to determining the impulsions. He first ascertained that these are proportionate to the square of the velocity, begin-

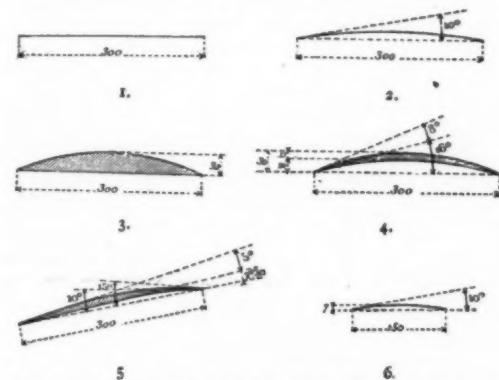


Fig. 5.—Sections and Dimensions of Various Surfaces Experimented Upon.

ning with a velocity of 7 meters (23 feet) and increasing same to 30 meters (98.4 feet). Our illustrations embody the experiments made with the two preceding plates. Fig. 3 refers to the plane surface and Fig. 4 to the curved surface.

The angle of inclination of the surface under consideration is found in the abscissa, and the coefficient ϕ in the ordinates of the formula $F = \phi SV^2$. The curves 1 refer to the vertical push, the curves 2 to the horizontal and the curves 3 to the total push resulting from the first two.

It will be noticed that at least in the case of the small angles, which are the only ones of interest to aeronautics, the curve of the horizontal impulsions assumes a parabolic form, while the vertical push is linear. In the curved plate, the vertical push becomes *nil* at an angle of -4 deg.

The maximum vertical push takes place at about 20 deg. Toward 30 deg. the curves break off. We are then in the period of instability. The curves begin again at about 36 deg., but after that they have little interest for aviators.

M. Rateau has deduced from these curves the following formulae, which represent the vertical and the horizontal pressures:

$$F_v = K S V^2 \delta \text{ with } \delta = \alpha + \alpha'$$

where α_0 is the angle for which the vertical push is null, and

$$F_h = K S V^2 (r \alpha^2 + t \delta + s)$$

or

$$F_h = K S V^2 (r \delta^2 + t \delta + s)$$

which exactly represent the formulae given by M. Soreau with this difference, that S cannot become a negative quantity according to the foregoing experiments.

K is a constant coefficient in relation to surfaces of equal dimensions. This coefficient increases with the bending, as we already knew.

For plates of 500 millimeters (19.685 inches) and 300 millimeters (11.811 inches), the value of K is 0.180, and for plates of 500 \times 150 millimeters (19.685 \times 5.906 inches) the value of K is 0.275. In the first case the elongation is equal to 1.67, while in the second the elongation reaches 3.34 in value, which clearly demonstrates the great advantage of large bendings.

Lastly, many series of experiments have been made

with plates of various forms and we give in Fig. 5 the profiles, with their dimensions and their angles, which have served to determine them.

Fig. 6 shows the results obtained, the abscissa indicating the angles formed by the chord with the direction of the current, while the ratio of the vertical and horizontal pressures is given in ordinates.

The curve is very pointed for a plane surface. The

donors.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from L'Automobile.

NOVEL PRODUCTION OF PRECIOUS METAL LEAF.

FOLLOWING is an explanation of the production of all kinds of metal leaf, leaf gold, leaf silver, and all metals of the platinum group in leaf form, as well as alloys of these, according to an entirely new method:

In the manufacture of leaf metal for ceramic luster preparations and ceramic bright precious metal preparations, proceed as follows:

On a smooth surface which neither heat nor acids will affect, apply the solution of a luster preparation, that is, resinate of a metallic oxide dissolved in an essential oil, and burn it in.

Then the solution of a bright precious metal preparation is applied to the burnt-in luster surface and likewise burnt in, i. e., the non-oxidizable bright metals, like gold, platinum, in ordinary fire, the oxidizable, osmium for instance, in a closed muffle, which is filled with a reducing or neutral gas, such as illuminating gas, hydrogen gas, or carbonic acid.

The thin film of precious metal thus produced, says Die Edelmetall Industrie, can then readily be detached by eating away the luster layer by treatment with acids. In the most complete manner the detachment of the little film is effected by coating the thin layer of precious metal before the etching away of the ground with a thin covering of collodion or varnish. We can also obtain an electrolytic, reinforced or primarily produced metal layer, in the same manner, by coating with collodion and eating away the background, which is soluble in acids. If then the eating off of the luster background is attempted, the film of precious metal will be in faultless condition, because the collodion coating perfectly protects it against tearing.

To remove the collodion skin either use acetic acid ether or simply burn it off. For many purposes we can,



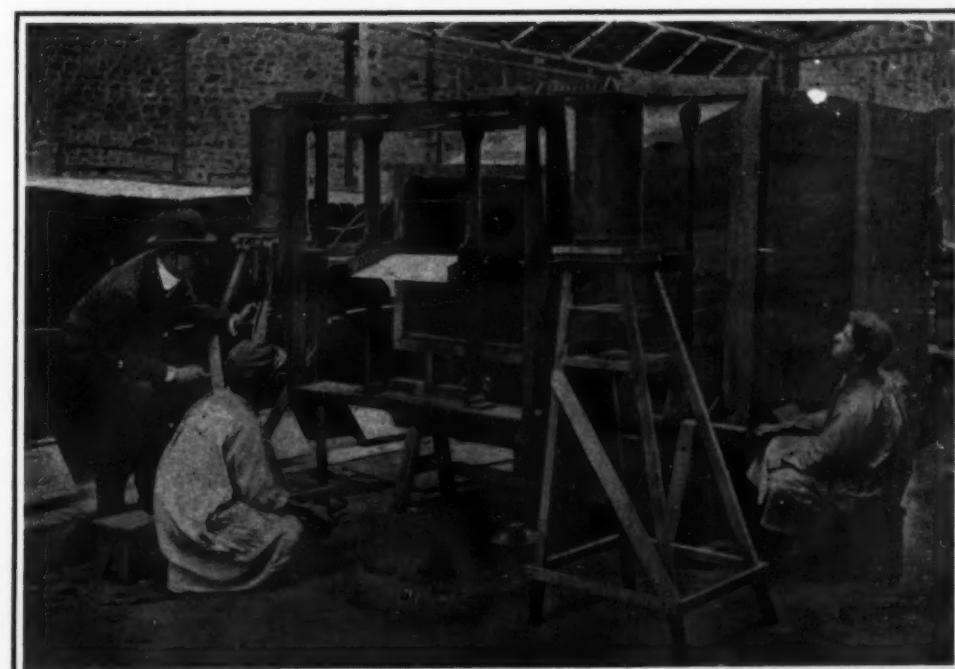
Fig. 6.—Relations of Vertical to Horizontal Components in Various Surfaces.

however, leave the coating, which is invisible because the precious metal film is by it made more durable and easier to work. The precious metal films thus obtained are of absolute uniformity, which is never the case with those produced by the gold beaters' process.

The luster preparations of all metallic oxides, which after burning in are soluble in acid, can be used for this process.

The same effect as with the lusters is obtained by the employment of fluxes readily soluble in acids, such as borosilicates, phosphates, etc., which are applied and burnt in in the same manner.

For eating away the luster background, use mineral or strong organic acids, acetic acid for instance.



THE RATEAU APPARATUS FOR AERODYNAMIC RESEARCH.

One can by this means obtain every desired combination or alloy and consequently every shade of color from one or more precious metals in leaf form by suitable combination of the solutions of the precious metal preparation. This is of unmeasurable importance for the precious metal industry. Effects may be obtained that are quite impossible by any other method, and especially for the production of inlaid

work and similar decorations the process offers great advantages. Leaf osmium cannot be produced in any other manner because osmium is non-fusible, and by reason of its non-fusibility and brittleness, it cannot be adapted to the gold beaters' processes. By the method just described, leaf osmium can be produced as easily as any other leaf metal.

By applying the solutions of the precious metal

preparation in any desired figures, decorations of any description may be obtained, which can be applied to innumerable objects. Even entirely novel decorative systems are possible, because these thin pattern films can be modeled on to plastic foundations, and by this means relief work can be made with little trouble than can otherwise be obtained only by stamping or *repoussé* work.—Die Edelmetall Industrie.

WATERPROOFING CONCRETE STRUCTURES.*

A REVIEW OF MODERN METHODS.

BY C. G. DERRICK.

THE rapid development in the use of cement plasters and concrete for construction purposes has brought forth many new problems for solution. Perhaps one of the most important has been that of constructing water-proof structures, that is, structures which are proof from percolating water as well as from dampness. Yet in another light, this problem of water-proof construction applies equally well to the use of building materials other than cement.

The reasons for water-proof construction are many, and differ with the locality. In general it is very desirable to make reservoirs of material impervious to water. Along the sea coast the problem becomes very acute. Cellars to our modern business blocks are sunk far below the high-tide mark, and in certain cases under the writer's observation sub-basements were subjected at high-tide to the pressure of 18 feet of water. But such basements are of great value for storage and must be water-proof. Again, in certain places water and sewage mains must run in parallel and it is of the greatest importance that no contamination of the water supply should be possible. But perhaps the greatest argument for water-proof construction is durability and permanency. The reinforcing, which makes the extended use of cement concrete possible, must remain intact. But many observations have shown that this is not the case where the concrete is pervious to water and exposed to the action of chemicals in solution in the water. From this viewpoint water-proofing is very necessary to prevent the disintegration of reinforcing as well as the cement itself.

To construct water-proof structures for one or more of the above reasons has long been the task of the engineer. A question much discussed is whether or not it is possible to construct buildings from cement concrete alone which shall be water-proof. Beyond a doubt this is possible, for a carefully applied cement plaster lining of foundation walls has in many cases rendered these walls impervious to water. But such work requires special materials and workmanship. The sand and stone must be carefully graded and applied with the greatest care. A member of a prominent New England firm summing up the whole matter stated that it is not a question as to whether or not cement concrete may be made water-proof by the careful gradation of materials in the hand of expert men, but that with the ordinary type of unskilled labor employed water-proof construction is impossible. This statement was made in spite of the fact that this company held the record for the construction of water-proof structures in that neighborhood. Further, he stated that anything which could be added to the concrete to insure its being water-proof without greatly increasing its cost was to be desired and had an almost unlimited application.

It is a well-known fact that alum and soap mixtures have been used for water-proofing since the middle of the last century. Very probably at first they were used as external washes, but more recently they have been applied to concrete itself, by means of the water used in the mix. Various proportions of alum and soap have been recommended, but in every case there is a distinct lack of cleanliness about such procedure, caused apparently by a lack of the knowledge as to how the water-proofing effect is brought about. The water-proofing effect is due to the precipitation of the insoluble aluminium salts of the organic acids occurring in soap. These salts partially fill the pores of the concrete and give the finished concrete a repellent action toward water. Hence it is evident that the alum and soap should be used in the exact proportion demanded by the chemical equation. But to determine this proportion the analysis of the soap must be known as well as the composition of the alum. Moreover, the best practice to-day recommends that the amount of alum and soap precipitated into the concrete should equal but not greatly exceed 2 per cent of the neat cement used in the ordinary mix for concrete.

But the use of alum is needlessly expensive. Alum has the formula $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ in which the desired material, aluminium sulphate, $Al_2(SO_4)_3$, makes up only 36 per cent of the whole. It would be far better to use alum sulphate, which as a commercial product has the formula $Al_2(SO_4)_3 \cdot 18H_2O$, in which there is 51 per cent of the desired $Al_2(SO_4)_3$. Even with this modification the method is much more expensive than many others which give just as good results.

Until very recently the use of the tar and felt seal method for water-proofing buildings has had universal application. It can be applied to structures built of any ordinary building material and if successfully applied gives very satisfactory results. This seal is applied by two different methods. First, it may be applied to the outer surfaces of the foundation walls and floor. Second, it may be applied to the inner surfaces of the same.

One method of applying this seal to the outer surface of walls and floor consists, in brief, in first building a small retaining wall of some cheap material which will support the seal until the real foundations are put in place, as well as to protect it from the outside wear. This retaining wall is mopped with tar, to which is applied tar paper which is then carefully mopped with hot tar to seal all joints. Several successive layers of paper and tar are applied according to the specifications. Great care is taken, or should be, to insure each layer's being water-proof before the next is applied. When the seal is completed the foundation walls are built snug against it. The seal makes a complete water-proof shell within which the foundation walls and floor rest.

In the second method the shell is constructed within the finished structure. To protect it and hold it in place a retaining wall is built within the foundation walls, and this retaining wall varies in thickness according to the external water pressure.

Practice differs as to which method shall be employed, but many firms desire to apply the seal to the inner surface of the foundations as given in the second method, the reasons for which will appear presently. With the first method careful overseeing is necessary to prevent the seal from being punctured while the foundation walls are being built, for often one firm applies the seal and another puts in the foundations. If the seal is punctured, it is very difficult to fix the responsibility, and this is one reason why the seal method is undesirable. The strongest argument against the use of the seal is the difficulty of patching it after the structure is completed and the seal becomes punctured. A break in the seal is made evident by a damp spot on the wall, or, often, percolating water. At this point the walls are torn away to expose the seal; but as often happens the puncture is not at this point—so the wall must be removed until the leak is found. It is very evident that this process is much simpler in the second case where the shell is within the foundation's walls and supported by a thin retaining wall. In either case the cost of repairing the seal is very great and the uncertainty of quickly locating the leak makes the method undesirable. In one case, where the writer was called in to assist after three weeks of steady searching the leak was found. In another case—that of the Shawmut Bank Building in Boston—where the seal was applied to the outer surface of the foundations—the writer found the only way to make the completed structure water-proof was to apply a patent water-proof cement coating to the inner surface of the brick walls of the entire cellar. The objections to the use of the second method of applying the seal are that much valuable storage space is taken up by the retaining walls and that the reinforcing in the foundation walls is exposed to the action of the ground water.

The result of the general dissatisfaction with the seal method has resulted in the discovery of many new methods of water-proofing, and to-day there exist several firms making chemicals which, when applied to the cement, will insure its imperviousness to water.

The present methods are very different but fall into two general groups, namely, those that are applied as external washes or paints and those that are incorporated into the cement during the mixing.

Under the first division, the use of alum and soap washes, cement grout, finely suspended slaked lime or magnesium carbonate, asphalt paints and interior coatings of tar or asphalt are the most important. In the cases where the external pressure due to the water is small these methods will give more or less water-proof structures, but in every case they are exposed to wear and soon become punctured. Here again the reinforcing is exposed to the action of the ground waters which seep through the concrete.

The modern water-proofing that is giving the most satisfactory results is that in which the water-proofing material is made a constituent part of the concrete. Such material must be insoluble in water and possess permanency toward heat, atmospheric conditions, and the substances carried in solution in the ground water—weak organic acids, alkalies, etc. Moreover, they must have a harmless action upon the concrete itself, that is, they must not decrease its temporary or permanent strength. With these qualifications in mind the problem becomes much restricted for the chemist, and the result has been several very successful methods of rendering the concrete, within itself, impervious to water.

This type of water-proofing is accomplished by three different general methods. By the first the foreign material may be added to the concrete by means of the water used in the mix, either as a true solution or as a suspension. In such cases where the water-proofing material is added as a true solution, the chemicals must react with each other or with chemicals in the cement to produce the desired insoluble water-proofing compounds. Few processes of this type are now employed and they are trade secrets. One firm, which well illustrates the recent development in this type of water-proofing, first used a true solution, next employed a treated cement, and at present uses a prepared cement ready for application as a plaster, which consists of cement, sand and water-proofing compounds. Many reasons may be advanced for this development, namely, secrecy, insurance of equal distribution of water-proofing compounds, and profits upon the cement, sand and chemicals.

Under the second subdivision of this first general method, the alum and soap mixtures are representative examples. But the use of lime and soap mixtures is by far the cheaper and of exactly the same water-proofing value. The product formed by these mixtures is a calcium soap, which is insoluble in water and very stable under ordinary conditions. But if used in a boiler room it must be protected by a considerable thickness of concrete where it underlies the fire box. Ordinary, insulated steam pipes do not affect these soaps. Very recently experiments have shown that colloidal clay may be used as a water-proofer with excellent results. Yet many tempting dangers follow in its course, since it offers a great incentive to fraudulent cement making. Moreover it is not always accessible and unskilled labor is hardly to be trusted with its use.

In the second general method the foreign material is added to the neat cement by means of organic solvents. The water-proofing materials are in general paraffine, stearic acid, and waxes. A solution of these in benzine is applied to the neat cement and the organic solvent evaporated while the cement is agitated to insure equal distribution of the water-proofer. It is very evident that this method is costly because of the materials and special apparatus needed and it can never hope to compete with the calcium soap method.

Lastly, in the third general method, the water-proofing material is added by mechanical mixing of the foreign material and the neat cement, of the foreign material, neat cement and sand, or of the foreign material, neat cement, sand and stone. By whatever process employed, its success as a water-proofer depends upon its thorough and equal distribution

throughout the concrete so as to render each part of the finished structure equally impervious to water. The literature upon this subject very early noted the use of mixtures of slaked lime and waxes, which were ground with the neat cement, the idea being, that in the presence of water, insoluble calcium salts of organic acids would be precipitated within the concrete. Such a method introduces needless materials of excessive cost. In the place of lime and waxes should be added calcium soaps which are a commercial product and very cheap. Many trade products such as the Medusa water-proofing compounds are undoubtedly nothing but the lime salts of certain organic acids or their equivalents. For a detailed description of these compounds and their use, the prospectus put out by the Medusa Water-proofing Company will suffice.

The writer has experimented with each of the foregoing classes of compounds used to make cement impervious to water. The substances used being paraffine, beeswax, carnauba wax, spermaceti, linseed oil and salts of organic acids which were applied according to some of the above-mentioned methods. A qualitative test adopted to show the presence of water-proofing characteristics consisted in making small cup-like

pieces of cement plaster treated by each of the above chemicals. Those molds were filled with water, after having thoroughly set, and if the chemicals gave the cement plaster water-proofing characteristics of any value no percolation or dampness should appear on the bottom of the molds no matter how long the water remained in them. In general a 1:1 or 1:2 mix with a good sharp sand was used in making the molds. Molds containing the following percentages of water-proofing compounds were used: 1-100, 1-16, 1-2, 1, 2, and 5. In every case marked water-proofing qualities were noted even with the percentage of material as low as 1-100 per cent, but more satisfactory results were obtained only when the water-proofing material ranged from 1-2 to 2 per cent of the neat cement employed. In every case 5 per cent of foreign material destroyed the strength of the plaster, while 2 per cent or under apparently made no difference in the tensile strength tests. The presence of the water-proofing material had a marked effect on the rate of the preliminary hardening which was always checked. Of all the chemicals used, the lime soaps appeared the most desirable, and with these quantitative tests were made. The first test was to patch a leaking brick wall which had been

previously coated with a plaster of a water-proof cement. After checking the flow of water, the leaks were coated with the treated cement containing 1 per cent of lime soap using a 1:1 mix. After successfully completing this test, the original concrete on a piece of new construction was treated with the same chemicals. The result was a water-proof structure quite impervious to the external water pressure of eight feet. Further, this test showed that concrete may be more easily water-proofed than cement plaster and that it requires no greater percentage of water-proofing materials.

The question now naturally arises as to how such water-proofing is brought about. To this question no correct answer can be given at present. However, it is evident that the small percentage of foreign material added to the concrete does not fill the voids in the same, completely nor to any appreciable extent. Yet one characteristic of water-proofed concrete is very evident. The capillarity, which causes the water quickly to creep over and through ordinary concrete, is destroyed in the case of the water-proofed product. In this direction, the cause of water-proofing may find its ultimate explanation.

THE ARMY SIGNAL SCHOOL.*

ITS METHODS AND RESULTS.

BY CAPT. A. C. KNOWLES, SIGNAL CORPS, INSTRUCTOR ARMY SIGNAL SCHOOL.

Six years ago the Army Signal School had no existence. It may truly be said that to the great majority of our army officers, particularly in the infantry and cavalry, the signal corps itself was a vague, if not unknown, quantity. But few of us ever came in contact with its personnel; the scope of its work in time of peace, in domestic disturbances, in times of disaster or in time of war seldom if ever was presented to the public (and I refer here particularly to the army public) in a way which stamped it upon their minds as an invaluable auxiliary in a modern army.

Until recent years there seems always to have existed in our own, as well as other armies, an unjust contempt for any soldier who did not actually fight with his own hands. The spectacular is still a prominent relic of barbarism, which sways our imagination and influences our better judgment. The awe-inspiring picture of our war hero dashing madly along the front of his troops, urging them on to victory, is still a vivid recollection. In the recent Russo-Japanese war the now world-renowned general did no such thing. We see him sitting quietly in his tent twelve miles behind the firing line, away from the immediate scene of some local action, away from the noise and confusion of battle, where, free from conditions which might urge him to command only a part, he controls the whole.

How infinitely necessary in all future wars of any magnitude will be that auxiliary arm which renders this control of a modern army possible. It is believed that the day is not far distant when another distinct combatant arm will be added to our service.

The modern battle-field has been frequently compared to a chess-board. On the one hand we have presented a picture of a fixed number of pieces, each occupying its proper position, each moving in accordance with prescribed rules, and the strength of each a positive

factor. The disposition, the probable intentions of the opposing forces; in brief, the general and special situations on each side, are at all times accurately known to the master minds who besides have their respective forces constantly under their absolute control. On the other hand, how confusing the game waged on the battle-field! After the first few moves, doubt and ignorance usually prevail; units moving independently, retreating when they should advance, advancing when they should stand fast, complicate and hamper the most carefully laid plans at every turn. The master mind no longer has absolute control of his pieces, he knows but little of his enemy, and the game resolves itself into blind man's buff. No matter how wisely the plan of action is prepared, the chances are few indeed against an enemy of equal strength, pluck, equipment, etc., actuated by a mind in touch with all the parts.

What a contrast between these two pictures! The first shows us a perfect system of information, with perfect means of conveying it and perfect control of the movements of the men. The second portrays these lacking or very imperfect.

The importance of perfecting these instruments of battle cannot be exaggerated; and ranking as an instrument of the greatest importance in the "service of transmission," is the signal corps.

The signal corps is standing at the threshold of a new era, an era which is full of possibilities and usefulness. It has become a corps highly technical in character, and as its future depends upon those instructed with the work, its commissioned personnel should be systematically trained in this work. The Signal School is a means to this end, its existence being due to the efforts of those who look far into the future.

The signal corps especially needs creative and constructive students of the practical sort, who, while being able to retain a thoroughly disciplined attitude at

all times toward the opinions of superiors, will nevertheless push forward into new lines of development, which alone can insure keeping progress with the armies of other nations. The two objects kept in view in forming the curriculum of the Army Signal School have been the following: (1) To prepare each student officer for the active and technical duties required in case of immediate declaration of war; (2) to investigate and co-ordinate the whole subject of lines of information by thoroughly practical methods, with a view of realizing better and more efficient tactical and strategical methods of operating armies in the campaign.

The value of the course to an officer who may be fortunate enough to secure the detail is, to me, pronounced in character, even though he never willingly elects to become a member of, or temporarily attached to, the corps. I wish to forestall the possible charge of rhapsodizing, and if I appear to be over-enthusiastic in comment, it should be borne in mind that my comparison is in the nature of "before and after."

The creative and constructive student referred to above is here afforded every opportunity and encouragement in the matter of original thought and research. The school is now equipped with the finest laboratory in the service. A company of trained signal corps men is at its command whenever its services are required in the experiments and problems in the field. The student is offered a strong stimulus to form his own opinions on military subjects, and a respect for the opinions of others.

COURSE OF STUDY.

The course of study is embraced in four departments, as follows:

- I.—The Department of Field Signaling.
- II.—The Department of Signal Engineering.
- III.—The Department of Topography.
- IV.—The Department of Languages.

SUNLIGHT IN A TEST-TUBE.

IN 1774 a theologian, described as of an eccentric, restless, fiery nature, turned the rays of the sun by means of a magnifying glass upon some red precipitate imprisoned over mercury in a tube. His curiosity was rewarded after a while by the appearance of bubbles of gas, and Joseph Priestley had discovered oxygen. The importance of the discovery to medicine among other sciences was of course very great. About 120 years later physicists calculated that the heat received by the earth under a high sun and clear sky was equivalent to about 7,000 horse-power per acre, but until recently nobody has got a step farther than did Priestley toward utilizing this energy for practical purposes. It has been suggested, however, that some day our centers of industrial activity may be transferred to the burning deserts of the Sahara and the value of land determined by its suitability for the reception of traps to catch sunbeams. The practical utilization of the sun's influence is certainly of far greater concern to the human race than, for instance, aviation. The conquest of the air, like that of the sea, must be dependent upon our supply of energy. Fuel, in the shape of coal and petroleum, is the chief source of energy at the present time, but it

is utilized in a clumsy and extravagant way. The tides and waterfalls will no doubt in time be made to do their share, but even the energy of these is insignificant compared with the enormous energy received from the sun. Is the notion of utilizing this energy too chimerical for serious consideration? In face of the measure of success already gained in regard to securing and controlling natural forces it would surely be over-timid to answer this question in the affirmative. Further, although the investigation of the subject does not hold out the promise of the "sporting time" which experimental aviation appears to give, yet there is a band of busy workers giving keen attention to it. Any day the startling announcement may come that human ingenuity has succeeded in boiling the kettle with but a few minutes' exposure to the accumulated energy of the sun's rays. A bottle of water may set the house on fire just as a pipe may be lighted by means of a glass lens. A comparatively simple experiment, but of great significance, has recently been performed which may mark the beginning of a series of wonderful practical achievements in this direction. It has been shown that by focusing the sun's rays on some crystalline silicon contained in a vacuum in a glass vessel the crystals fused in a

few seconds, showing that a temperature of 1,450 deg. C. had been obtained. In a similar experiment copper and cast iron were fused almost instantaneously. The success of the experiments appeared to depend upon the fact that the substances were contained in vessels emptied of air, for on admitting air the temperature did not exceed 675 deg. C. From the test tube to the steam boiler, the dynamo, and the electrical cell is but a step, and Priestley's classic experiment of 1774 may receive a fame not yet reached by any other laboratory success.—Lancet.

According to a recent report in *L'Engrais*, a discovery has been made of an important nitrate bed in California, and a company has been formed to exploit it. The quality of the nitrate is said to be fully as good as the Chilean product, and considerable importance is attached to the discovery, in view of the fact that water is readily obtainable near the fields, and steamers of moderate tonnage can sail to within a very short distance of them. The Panama Canal will be open in a few years' time: this is a decided advantage. The present yearly production of the Chilean fields is about 1,650,000 tons, and the new beds are estimated to contain 20,000,000 tons.

* General Electric Review.

GROWING AND GATHERING SPONGES.

A NEW INDUSTRY.

Continued from Front Page.

This optical instrument—an important one too—is nothing more or less than a water-tight cylinder with a plain piece of window glass fastened in one end. Sometimes a simple water bucket with the bottom knocked out answers the purpose. In seeking sponges in rough water, this device is placed upright in the waves, and the head of the fisherman thrust into it as deep as possible beneath the surface. Looking through the glass in the bottom, the hooker sees the bed of the sea to a depth of fifty feet. This is explained by reason of the fact that the flat surface of water pressed under the glass is absolutely devoid of those ripples and irregularities which are caused to appear on the surface by the wind and tide. As soon as a sponge is spied through the crude marine telescope, the sponger grasps his hook and brings it into play. By reason of his trained eye and skillful hand, it is rarely that he misses, even while the boat is being propelled. This old method of gathering sponges is tedious and trying, and requires a patience beyond belief. To maintain one's self in a shallow skiff without upsetting it, and at the same time to spy the game through the bottom of an inverted bucket, and further, to catch it on the end of a fifty-foot pole while the boat is in motion, is a complication of feats of which not many are capable.

Up to a few years ago this antiquated method of catching sponges was followed along the Florida coast. In fact, it is still employed to some extent by the natives in that section. These folk go out from the harbors in small schooners, which are built with large decks for carrying the catch. The crew of such a craft consists generally of half a dozen men and a cook. Every morning at daybreak they launch their dingies from the schooner. Each of these small craft is manned by two, known in the fisherfolk lore as "hooker" and "sculler." The former remains on his knees with his head thrust down into his spyglass most of the livelong day, while the "sculler" slowly propels the boat, unless their efforts have been unusually successful, when they return to the schooner and "lay up" before sundown. The main craft sometimes stays offshore for eight weeks catching its load of sponges.

In Florida, however, most of the sponge fishing is done to-day by professional Greek divers. These experienced foreigners, driven out of the Mediterranean by the governments bordering on that sea, have immigrated to Florida for the purpose of applying their vocation in American waters. With years of training in the deep waters of the Mediterranean Sea, they have become experts in the art of sponge gathering. In a diving suit called "shafander," they can easily secure sponges—and choice ones too—that cannot be reached by American hookers. The diving suits worn are of the most modern and perfect make, heavily weighted with lead. Even leaden-soled shoes are worn. The divers carry with them to the bottom a large mesh sack, into which the sponges are placed with both hands just as if they were oranges. The boats follow along on the surface, pumping fresh air to the divers and hauling up and lowering the sponge bags whenever full or empty. The diving suits worn by these sponge gatherers are so perfect, and the water

so clear at the depth to which the divers descend, that there is little risk of life except from sharks. The water where the sponge abounds is infested with man-eaters, and many are the thrilling escapes of the men who walk the bottom of the sea. These sponge fishers carry no weapons, because a weapon that would cause death under water would have to draw blood. One shark killed, the first trace of blood would attract a dozen more. The diving suits are too heavy for

so called because of its close resemblance to the wool of that name. Notwithstanding the fact that this variety is much cheaper, it is often preferred to the Turkish sponge as a toilet article. Next in order of value come the velvet, yellow, grass and glove sponges. The velvets are very scarce on the Florida coast and vary in price according to quality, while the grass and the glove sponges sell as low as a few cents a pound. It takes a good measure of well-dried sponges to make a pound.

Experiments have recently been conducted for the purpose of testing the feasibility of transporting sponges alive in aquaria. These experiments are reported to have been a success, and it is now possible to transplant the valuable varieties of Turkish sponges in the sponging grounds of American waters.

Not only were the experiments of transplanting sponges successful, but an eminent biologist, Dr. H. F. Moore, has conducted a series of experiments, which have resulted in the production of a rootless sponge. The root of a sponge is its most vulnerable part, and at this point it first begins to tear. A rootless sponge, therefore, will far outlast the common variety. Dr. Moore's method of producing the rootless sponge is to cut the animals into pieces two cubic inches in volume. This is done by means of a very sharp knife while the sponge is alive, and has at least one face covered by the original skin. A slit an inch deep is made lengthwise in each cutting, which is then placed astride a wire. This slit is then closed by a piece of aluminium wire, so that there can be no rust or corrosion of any sort. Within a week the cutting heals around the suspension wire. Long wires strung with these cuttings are then driven into the shallow sea bottom, about fifty feet apart, the cutting being suspended free from the bottom. In eighteen months these seed, as it were, attain twenty-five times their original weight. When this method of artificial sponge growing is carefully carried out, ninety-five per cent of the cuttings will not only survive, but will grow into a perfect ball or ellipsoid with no vulnerable point, their roots being on the inside. Such a sponge of the sheep-wool variety will last for years. All of the species of sponges can be reproduced in this extraordinary way.

These valuable fishing grounds have been so overfished in and out of season, that the Congress of the United States found it necessary to pass stringent laws to protect the industry from annihilation by the Greek divers. The new law prohibits these divers from working after the first of May until the first of October in water that is less than fifty feet deep, and the revenue cutter service will have vessels to patrol the Florida waters to see that the law is strictly enforced. This law was made not only for the protection of the sponge industry itself, but likewise for the protection of American sponge fishers, who rely on the sponge market for a livelihood, and who still gather their prizes with a harpoon.

So many Greeks have immigrated to the Florida sponge waters from the Old World to follow their calling in the New, that one may see in the Greek quarters at Tarpon Greek houses, Greek costumes, and hear only the Greek language spoken. Even the boats from which the divers work are brought from Greece.



THE AMERICAN WAY OF FISHING FOR SPONGES.
USING THE WATER GLASS.

rapid movement. When one of the man-eating sharks appears on the scene, the diver's only course is to remain absolutely still, for a shark will not disturb anything it thinks dead. As one of the oldest sponge fishers of the Greek race states, it requires an extraordinary amount of nerve for a man alone at the bottom of the sea to keep still all the while a fifteen-foot hungry shark is circling him and lashing him with its tail.

As the small boats carry their loads to the main ship the sponges are placed on the deck, where they are left until all the slimy matter they contain has drained off. While the sponges are dying, they give off a strong odor of ammonia, which after a few days changes to the more pleasant smell of seaweed. The schooner then returns to its base of operation, and places its catch in pens made of stakes driven in the shallow water near the shore, so that the flowing tide washes the sponges as it comes and goes. This washing takes about one week, after which the sponges, one by one, are thoroughly squeezed out and beaten with sticks until all the living matter has disappeared. After this process they are strung in bunches upon pieces of rope about six feet in length, and piled upon the shipping wharves, to be sold at auction to persons known as the packers' agents, who ship them to their packing houses. Here they receive their last treatment, bleaching, which is accomplished by a solution of lime and sea water. If the solution is made too strong with lime, it makes the sponge harsh and easy to tear. But notwithstanding this fact, it is the custom of many of the packing houses to use large quantities of lime. The sponges are then made to weigh more, and they are sold by weight.

The finest sponges in the world are the Turkish. They have brought as much as \$50 a pound, but they are scarce. Next in quality is the sheepwool variety,



SPONGE DRYING YARD AT KEY WEST, FLA., SHOWING BALED SPONGES.



HOW SPONGES ARE GATHERED AND GROWN.

GREEKS ENGAGED IN TRIMMING AND SORTING SPONGES.

LEONARDO OR LUCAS?

THE LEONARDO DA VINCI BUST.

A FEW months ago, Dr. Wilhelm Bode, director of the Kaiser Friedrich Museum in Berlin, while sojourning in England, acquired from Mr. Murray Marks, a London dealer in antiques, a tinted wax bust representing a young girl wearing a wreath of flowers in her hair. Mr. Marks, a connoisseur of great experience and of excellent reputation, declared this bust a work of Leonardo da Vinci; and Dr. Bode, an authority on Italian sculpture of the Renaissance, felt so certain of its genuineness that he purchased it for his museum at a price of about \$40,000. He exhibited the new acquisition at a prominent place, designating it as a bust of Flora, by Leonardo da Vinci.

It appears that a short time before the bust had been offered to the British Museum, which, however, declined to buy it. When it became known that the bust had been sold to Germany, part of the British public were perhaps inclined to criticise the action of the British Museum severely. In view of later developments, however, it behoves critics to suspend judgment, to say the least, and many are now congratulating the British Museum on its escape from what may turn out to be one of the skillful impositions in the history of art.

In a letter to the London Times, Mr. Charles F. Cooksey, an appraiser of Southampton, asserted that the so-called Leonardo bust was in reality the work of Richard C. Lucas, a nineteenth century sculptor and modeler. The artist's son, Albert D. Lucas, now eighty-one years old, confirms Mr. Cooksey's account, and says he remembers that in 1846 his father modeled this bust on the commission of an art dealer named Buchanan, from a painting attributed to Leonardo da Vinci and styled "Madame Joconde" or "Flora." This picture had been owned by R. C. Lucas, and A. D. Lucas made a copy of it in oil, which was reproduced in the Illustrated London News. Mr. Buchanan bought the painting from R. C. Lucas, and it is now in the Morrison collection at Basildon Park near Pangbourne. (It may be remarked that according to Dr. Bode, this picture is the work of Giovanni Pedrini, one of Leonardo's pupils.) The fact that such a painting was in Buchanan's possession in 1846 is attested by its appearing in a catalogue of a sale of his in that year, where it fetched 640 guineas. A. D. Lucas further reports that his father, after having sold the picture, was asked by somebody—presumably Mr. Buchanan—to reproduce the painting in a wax sculpture. Guided by the copy his son had made, R. C. Lucas produced the work which is now in Berlin. A. D. Lucas states positively that he assisted his father in this work, and there is independent corroboration by Mr. Whitburn, who wrote to the Daily Mail he distinctly remembered watching R. C. Lucas at work on this bust, in the manner and at the date alleged by his son. The sculpture, however, was not taken by Mr. Buchanan, and remained on R. C. Lucas's hands. Upon his death it was sold by A. D. Lucas in 1888 to a Mr. Simpson, who died in 1904. At an executors' sale the bust was included in a miscellaneous lot which was bought for five shillings (\$1.25) by a Mr. Mann of Southampton. He disposed of it, at no great profit, to Mr. Long of the same town, from whom it passed, five years later, to Mr. Sparks, another Southampton dealer. Through an intermediary Mr. Spinks of London acquired the bust, and from him it was purchased by Mr. Murray Marks.

A. D. Lucas also relates that the bust was draped by his father (to spare the susceptibilities of some of his lady visitors) and that the bust was photographed in that condition. The photograph is found in an album of Mr. William B. Hill, an old friend of R. C. Lucas, and a reproduction of it was published by the Illustrated London News. Mr. A. D. Lucas gives a detailed account of his father's work on this bust, mentioning among other facts that it was tinted in colors mixed with turpentine, and also that it was his father's habit to put in his larger works in wax a core of soiled or waste wax, sometimes hardened with rosin and rolled up with shreds of old cloth or canvas. Dr. Bode's alleged Leonardo bust is more than life size.

Against this rather formidable array of evidence and testimony, what proof or argument is adduced by Dr. Bode and his friends? They do not for a moment admit that A. D. Lucas may be right, and assert that if R. C. Lucas made a bust at all, this was not the bust acquired by Dr. Bode, but a bad copy of it, and that the photograph reproduced in the Illustrated London News was taken from this copy. Naturally, the question arises: What, then, has become of this copy? On this point, however, the Germans hazard no hypothesis. They assert, on the other hand, that the quality and character of the work are distinctly indicative of Leonardo's time and style. Against this English critics object that for a skilled craftsman such as R. C. Lucas

was, it should not have been very difficult to reproduce in sculpture, with a good interpretation of the original style, a picture of Leonardo or his school. They also call attention to the fact that some of Dr.

first difference they note is one of quality and details, and is asserted to be obvious upon comparing Dr. Bode's bust with the published reproduction of the Lucas photograph; however, the photograph, while a poor one and, therefore, not very clear, does not appear to bear out the statements of discrepancy. Moreover, A. D. Lucas emphatically denies that there ever existed more than one such bust, and no persons have yet come forward with the assertion that they had seen or heard of a second bust. The second point raised by the Germans is that Dr. Bode's bust shows no trace of such a core as described by A. D. Lucas; here the British critics say that the test for the existence of this core does not seem to be a certain one, and that moreover A. D. Lucas did not say his father put a core of this kind in this particular bust. Finally, as a third point in their favor the Germans inform us that Dr. Bode's bust is tinted in water colors, whereas A. D. Lucas has asserted that his father tinted the bust in colors mixed with turpentine; here the English critics suggest a chemical test.

In the meantime, the controversy goes on merrily. The German Emperor, after inspecting the bust in the Kaiser Friedrich Museum, declared that Dr. Bode was undoubtedly right in designating it as Leonardo da Vinci's work. The British press is skeptical. The French press, while showing respect for Dr. Bode's other achievements, cannot refrain from taking a humorous view of the situation, and would probably feel disappointed if the final decision should be in Dr. Bode's favor. Even if he has been mistaken, this will not seriously detract from his merit as a connoisseur and historian. Equally great authorities have had to acknowledge error in similar cases, as witness Mr. Furtwangler's attitude in the matter of Saltaphernes' tiara.

GENERAL ANÆSTHESIA PRODUCED BY SPINAL INJECTION.

By injecting a solution of cocaine into the sub-arachnoid space of the lumbar region, surgeons produce a local anæsthesia of the lower limbs, pelvis, and abdomen, so complete that the most serious and complicated operations can be performed on all organs situated below the diaphragm. In the doses and conditions employed in practice, cocaine suspends the conductive power of the posterior roots of the spinal nerves, by which peripheral impressions are normally conveyed to the higher nervous centers. The success and safety of this method are not affected by the fact that the other functions of the lower spine are suspended, simultaneously with the conductivity of the posterior roots, for none of these functions is necessary to the preservation of life. An analogous assertion could not be made if cocaine affected the medullary centers, for these centers govern important vital functions, and their inhibition might rapidly produce serious injury. The inhibition of the respiratory center, for example, would cause death by asphyxia. Hence the surgeons who make use of spinal injections of cocaine inject the alkaloid, as a general rule, only in the lumbar region of the spinal cord, and in doses so small that it is impossible for a dangerous dose to reach the medulla by diffusion. Hence the employment of this method would appear to be necessarily restricted to the production of partial and local anæsthesia, but Prof. Jonnesco of Bucharest has recently published the results of a great number of general anæsthesias produced by him by spinal injection of the alkaloid stovaine. Jonnesco injects the solution in the upper dorsal region, between the first and second dorsal vertebrae. To counteract the effect of the stovaine upon the higher centers, a certain proportion of strychnine is added. The dose for an adult is one cubic centimeter of a solution containing one-half milligramme of neutral strychnine sulphate and thirty milligrammes of stovaine. Anæsthesia of the head and neck is quickly produced, especially if the patient is kept lying horizontally, with the head very low, after the injection. In most cases, from two to three minutes suffice. The anæsthesia continues for an hour and a half or two hours. The parts anæsthetized are usually motionless, although immobility is not always complete. In all cases, anæsthesia precedes immobility. Such symptoms as paleness of the face, nausea, sweating, and vomiting, which occur so frequently after spinal injections of cocaine, are exceptional when stovaine and strychnine are employed. The unpleasant after effects are of rare occurrence, and incomparably less serious than when stovaine is used alone. Jonnesco has not had a serious accident in more than four hundred operations on the head, neck, arms, and chest. In his opinion, the future method of producing general anæsthesia will be the method of spinal injection.—*Revue des Sciences*.



THE WAX BUST PURCHASED BY DR. WILHELM BODE FOR THE KAISER FRIEDRICH MUSEUM AT BERLIN.

Bode's previous Leonardo attributions have not convinced independent judges. The Germans stand on firmer ground when they point out differences of fact, as tests will here show clearly who is right. The



THE WAX BUST OF A GIRL IN THE MUSEUM AT LILLE.

Dr. Bode cites this wax bust, which is in the Wicar Museum at Lille, to prove some of his points. Writing of the bust now at Berlin, Dr. Bode says: "It is made entirely out of purified wax, painted over. The painting is only on the reddish-brown hair and on the wreath of flowers, which is almost perfectly preserved, and the coloring of which is identical with that of the well-known girl's bust at the Wicar Museum at Lille. Again, he says, "The technique, the casting, and the style of the painting in colors which are soluble in water, are thoroughly characteristic of the Renaissance, as the comparison with the small bust proves. Where the old dirt has not been removed . . . the color is quite petrified and covered by a dull brown hue, just as are the girl's bust (Lille) and most of the works in wax of the same period." Further, and still writing of the Berlin bust, Dr. Bode points out that "the charges brought against the antiquity of the bust on the ground of material and technique are either of no consequence or wholly inaccurate. Wax has been used as a medium since the earliest ages, and in the Middle Ages, and especially the Renaissance, it was greatly used."

THE BLOOD OF PLANTS.

RESEMBLANCE OF PLANTS TO ANIMALS.

BY DR. VICTOR GRAEF.

It has long been recognized that no sharp boundary line can be drawn between the animal and vegetable kingdoms and that the cleft which once seemed to separate them was an artificial one. It is now certain that a complete understanding of the vital processes of plants cannot be gained without reference to those of animals. It is well known, for example, that the process of respiration is essentially the same in animals and plants, both of which absorb oxygen and exhale carbon dioxide, formed by the oxidation or combustion of food and bodily substance. Prof. Palladin, of St. Petersburg, has recently discovered that this identity extends to the details and successive stages of the respiratory process.

In the higher animals oxygen is absorbed from the air through the lungs, but the combustion of the carbohydrates, fats and albumen of the food would be accomplished very slowly and imperfectly by atmospheric oxygen, because these substances are not very easily oxidized. Hence the oxygen must be converted into a more active form. This transformation takes place in the blood. The red corpuscles of the blood owe their color to the pigment hemoglobin, which consists of an albuminoid, globin, combined with hematin, a substance which contains iron and is not of the albumen class. The greater part of the oxygen which circulates in the blood combines with hemoglobin to form the bright red oxyhemoglobin, which gives arterial blood its characteristic color, but the oxygen is so loosely combined that it is easily set free, in the "nascent" or atomic condition, in which it readily combines with other substances. Carbon dioxide, carbon monoxide and other gases also form unstable compounds with hemoglobin, which substance is the principal vehicle by which oxygen is conveyed to the tissues from the air or water in which the animal lives, and carbon dioxide and other gases of combustion are returned to the surrounding medium. Each of these compounds of hemoglobin has its distinctive color, oxyhemoglobin being bright red, carbon dioxide-hemoglobin purplish red, the color of venous blood, carbon monoxide-hemoglobin very dark red, etc., and the absorption spectrum of each is marked by characteristic bands. As hemoglobin itself is red, the changes in color are not very striking, but in insects and crustaceans the blood is colorless except in the oxidized state, in which it is blue or brown.

Oxyhemoglobin, therefore, serves as a reservoir of oxygen, which is transferred to the oxidizable matter in the tissues through the agency of substances called respiratory enzymes or oxydases. But the complex organic compounds furnished by the food must first be prepared for oxidation by being split up into less complex substances, and this work is done in all living organisms by enzymes of a different class, which themselves consume no oxygen. An example is furnished by the zymase of yeast, which even in the absence of air resolves sugar into alcohol and carbon dioxide. Simultaneously with these processes of oxidation, energetic processes of reduction or deoxidation also go on in the organism, as can be shown by an experiment devised by Ehrlich. If a dye which is easily decolorized by deoxidation and regains its color on exposure to oxygen is injected into the blood of an animal, and the animal is immediately killed, its tissues exhibit their normal colors, and do not begin to show the color of the injected dye until after they have been exposed to the air for some time. In the living body, therefore, the dye must have been decolorized by reduction. This deoxidizing action is especially strong in the lungs, nerves and muscles. Arterial blood, protected from access of air, soon assumes the dark color of venous blood, in consequence of a consumption of oxygen by the blood itself.

In Palladin's experiment sprouting wheat was immersed several days in water, sterilized by the addition of a little chloroform. The albuminous constituents of the wheat were partially split up into less complex substances by the action of ferment contained in the grain, and the water assumed a dark red and then a deep brown color. In the first days of the experiment the color could be destroyed by stirring the water and thus exposing it more thoroughly to the reducing action of the growing wheat. One of the substances into which the albumen was split up was a chromogen, or colorless substance yielding a coloring matter on oxidation. This chromogen, oxidized by the agency of the oxydases present in the wheat, produced the dark red coloration of the water, which could be decolorized by reducing the pigment to its colorless chromogen. Pigments of this sort are very often de-

veloped in vegetable matter. Cut fruit and fruit juices rapidly become red or brown, but the production of the coloring matter can be prevented by cooking the fruit, and thus destroying the activity of the oxydases. In some cases, as in the darkening of sugar beets when cut, this change is very annoying, while in other cases it is very useful. The sap of the Japanese sumach or lac tree contains a colorless resin, laccol, which is converted into black glossy lacquer by an enzyme known as laccase. Bertrand, the discoverer of laccase, has shown that the color of black bread is produced by a similar process.

Reinke ascribed to these chromogens and pigments an important rôle in the process of respiration, namely, the function of combining readily with oxygen and subsequently setting it free in an active form for the oxidation of combustible matter. The chromogens are oxidized to pigments by the oxydases of respiration, and the substances which are ultimately oxidized and consumed are the products of the partial decomposition of the albuminoids by the action of other enzymes. As these pigments do not become visible until after the death of the vegetable tissue, they were formerly regarded as products of decay, but they are not seen in living plants simply because they are reduced to colorless chromogens as fast as they are produced. The death of the cell increases the activity of the oxydases and lessens that of the process of reduction; hence the pigment accumulates.

Hence it appears that respiration in plants, as in animals, is accomplished by successive stages. The complex food stuffs are split up by enzymes, without the aid of oxygen; different enzymes, called oxydases, bring about a combination of atmospheric oxygen with the chromogens, which are thus converted into pigments; by the deoxidizing action of the living cell the pigments are again reduced to chromogens, and the oxygen thus liberated attacks the substances derived from the complex food stuffs and converts them into carbon dioxide and water, the final products of normal respiration. The process and its various stages are identical in plants and in animals. The similarity of the vegetable chromogens to the substances which serve as reservoirs and vehicles of oxygen in the blood of animals appears more clearly if we compare the former, not with the hemoglobin of higher animals, but with the corresponding substances in the blood of crustaceans and insects, which is colorless except when oxidized. In general, plants more closely resemble the lower than the higher animals. Hence Palladin calls the cell sap the blood of plants.

To the same class of respiration pigments which includes the brown of cut fruit and the black of black bread and Japanese lacquer belong various pigments of higher fungi and lichens, one of which, litmus, is employed as a test of acidity and alkalinity. In higher plants pigments play the same part in respiration. One of these pigments is indigo, which exists in the plant as a glucoside, indican. This glucoside is easily split up into sugar and a colorless substance called indigo white, which is the chromogen from which indigo blue is produced by the action of atmospheric oxygen. The red madder dye, similarly, exists in the plant as a colorless chromogen glucoside. All red, purple and blue colors in flowers, fruits and leaves are produced by respiration pigments which are known by the collective name of anthocyan, and which are made blue by alkalies and red acids. The transition, however, is not as sharp as in the case of litmus and thus are produced the purple tones of violets and other flowers. Sometimes the blue anthocyan is so concentrated that it produces black tones, as in the pansy and the mallow. If a blue gentian or violet is dipped in weak acid the flower instantly turns red, while tobacco smoke, which contains ammonia, turns a red rose blue. The color of red and red-cheeked apples, cherries, cranberries and red wine is also due to anthocyan. All of these anthocyan pigments are converted by reducing agents, such as sulphurous acid, into colorless chromogens. In this way fruit stains and wine stains can be easily removed from table cloths without injuring the fabric. The anthocyan pigments have been little studied by chemists. In addition to the old researches of Gautier we have only Heise's recent work on the pigments of cranberries and red wine, and that of Glanand, the writer on the pigment of the mallow. The pigments exhibit a general resemblance, together with well-marked differences, and the mallow pigments exist in two very different forms. All of the pigments studied, however, are benzol derivatives and glucosides, and are closely re-

lated to the tannins and to the yellow pigments of flowers. It appears very probable, especially in view of the results of Wheldale's experiments in hybridization, that these yellow pigments are the chromogens of the anthocyan pigments. It is these chromogens which exist in the plant in combination with sugar, forming glucosides. In order to produce the pigment, the chromogen must be set free from the sugar and must be oxidized by a ferment. If either the chromogen or the ferment is absent, the result is an albino. If a white flower, resulting from a cross between a white-flowering and a red-flowering plant, is moistened with dilute acid it turns red, and acids produce the same effect in the white or green early stages of some red flowers. Such flowers evidently contain glucosides, which are decomposed by the acid, yielding chromogens, which are then reddened by oxidation. An increase of the red coloration may also be caused by stings of insects.

Sugar plays an important and imperfectly understood part in the genesis of anthocyan pigments. Overton has proved that in many cases the production of red pigment in the cell sap depends on the quantity of sugar present and can be increased by placing leaves or twigs in syrup. The excess of sugar appears to be converted into pigment. The same result is produced when the normal outflow of the sugar found in the leaves is obstructed, as by a wound in the bark sugar is accumulated and ultimately converted into pigment. The coloring of fruits also depends on the supply of sugar from the leaves, and the redness of an apple indicates the former presence of more sugar than could be consumed in respiration. Light and heat also influence the formation of anthocyan pigments, for, though many flowers assume as bright colors in shade as in sunlight, others which are white in the shade become pink in the sun. The formation of pigment, especially in the lilac, is checked by a very high temperature. The effect of light is probably due, in part, to an increased production of carbohydrates.

In addition to the presence of sugar, a low temperature is required for the production of pigments. Red Alpine flowers are found at midsummer on the heights, but only in spring in the valleys, and in spring the young shoots of many plants show red and purple tints. As the summer wanes the red pigment is again produced more abundantly, giving autumn leaves their gorgeous coloring. Here the lowering of the temperature is aided by the gradual separation of the dying leaves from the stem, which prevents the outflow of carbohydrates. The accumulation of organic matter causes an increased production of chromogens and, together with the low temperature, apparently accelerates respiration, or oxidation, and retards the compensating process of reduction. The result is an accumulation of oxidized chromogens, or pigments.

Normally, the chromogens combine with sugar and thus become inactive as rapidly as they are produced. In general all products of metabolism which are to be stored for future use are converted into an inactive form. The sugar formed in the leaves, for example, is converted into insoluble starch, which in the ensuing spring, when it is needed for the new growth, is reconverted into soluble sugar, and thus mobilized by the agency of ferments. By this method the organism protects its active parts from an accumulation of products that would paralyze its activity, just as the chemist must provide for the removal of the products of a reaction if the reaction is to be continuous. If half of the external pores of a living creature are stopped death quickly ensues, and the activities of yeast and mother of vinegar are checked by accumulation of their products, alcohol and acetic acid.

Like a thrifty housewife, the living cell keeps its chromogen locked up (by combination with sugar as a glucoside) and gives it out (by the decomposition of the glucoside by enzymes) in small quantities, as it is required for the processes of oxidation, so that very little chromogen is in evidence, except in spring, when oxidation is especially rapid. This wise guiding principle, the soul of the plant, dies with the plant and can be paralized by chloroform or cold. The disintegrating enzymes continue their work after the death of the organism, so that a zymase, or active ferment, can be extracted from dead yeast cells, but this work is unco-ordinated and purposeless, because it is no longer directed by the higher authority of the living protoplasm.

The chromogens are rapidly set free and oxidized, and the dead tissue turns black. Often one enzyme destroys another as if the servants of protoplasm, to

use Palladin's expression, were quarreling after the death of their master. It appears, then, that the red cheeks of apples and those of our children are produced by entirely similar processes, and that blood is

not peculiar to the animal kingdom. Here, as everywhere, the truth was discerned by popular instinct long before it was discovered by science. The farmer gives the name "bleeding" to the exudation of sap from cut

stems, branches and roots, and wine is called "the blood of the grape"—a designation which acquires a new significance in the light of modern research.—Translated from Prometheus.

LIGHT PRESSURE AND COMETS' TAILS.*

WHY A COMET'S TAIL ALWAYS POINTS FROM THE SUN.

BY ARTHUR STANLEY EDDINGTON, M.A., M.Sc., F.R.A.S.

Or the various theories that have been put forward in order to account for the repulsion of comets' tails, besides the electrical theories, probably the most popular is that which ascribes the streaming away from the sun to the effect of light pressure. When radiation of any kind, sunlight or the heat from a fire falls on a surface, it exerts a pressure on that surface tending to drive it back. The light from the lantern which was falling on the screen just now presses against the screen, though the whole pressure is exceedingly minute; the whole pressure of sunlight falling on the earth is something like 150,000 tons weight, a force which is insufficient to make the earth budge so much as one hair's breadth from its path. But on the small particles of a comet's tail its effect may be of importance, because although the force of pressure decreases with the size of the particle, it does not do so so rapidly as the volume or weight, so that the effect on the motion is up to a certain point greater the smaller the particle. In the case of a particle 1/20,000 inch in diameter, the light pressure would just about balance gravitation; such a body would be neither attracted to nor repelled from the sun. For one whose diameter is 1/150,000 inch the repulsion of light pressure would be twenty times gravitation. You will remember that Bredichin found three classes of tails, of which the one most powerfully repelled the repulsion was eighteen times gravitation. We have only to suppose that the particles are of this order of magnitude, in order to account fully for his results. The existence of light pressure was deduced from theoretical considerations, but it does not depend on theory alone. The repulsion can be shown in the laboratory. Hull and Nichols actually tried to make an artificial comet, using the fine particles of lycopodium powder to show the repulsion of the tail. Unfortunately, although a repulsive force was shown, it was due mainly, not to light pressure, but to another effect.

With a particle about 1/150,000 inch in diameter, the repulsion is twenty times the attraction of gravity. Can we proceed to still smaller particles and account for forces of 36, 90 units, or still higher? It appears not. The size mentioned is about the limit, and for small particles we find, instead of increasing repulsion, less repulsion. Very minute particles offer practically no obstacle to the passage of light which, instead of pressing against them, bends freely round. I dare say by suitable assumptions, as to the density of the material, forces of 36 units might be accounted for, but the hypothesis of light pressure seems hardly competent to account for the greater repulsive forces. It must not, however, be supposed that the theory of light pressure is thus discredited; light pressure must act, and probably acts powerfully, on the minute particles which constitute a comet's tail, but a careful analysis of the strange motions and transformations taking place has convinced many astronomers that other forces are at work modifying and in some cases increasing the repulsion. In this connection the evidence that the repulsion is by no means a constant force has obviously a most important bearing.

At first it is with an almost overwhelming sense of the complexity of the problem that we sit down before this mass of material, striving to see through the twisting streamers and changing features to the few simple forces that govern it all. There are, however, a few signs of regularity in the photographs to which it seems most hopeful first to turn. The envelopes are wreaths or veils thrown out toward the sun and flowing away on each side. They are not like the streamers from the nucleus, for they seem quite detached, forming an arch over the head. The mode of formation may be illustrated by a well-known analogy. If you have a fountain consisting of a large number of jets of water in different directions, the limiting surface is a sort of dome in the form of a paraboloid, which, when seen sideways, exactly imitates the envelope of a comet. It is not merely a bounding surface beyond which none of the water is projected; the arch is thickened along this surface. When the water is turned on fuller, the arch rises; if it is turned off suddenly the arch does not subside, but vanishes; the water of course subsides, but the thickening vanishes.

It can hardly be doubted that the envelopes of a

comet are formed in this way; the explosion, from which the envelope results, throws out matter with fairly uniform speed in all directions, this matter being under the influence of solar repulsion, just as in the analogous case the water was under gravitation. By studying them we can learn something of the explosions that produce them; further, in them we are concerned with the general mass of fine particles, so that the study of the rather exceptional knots and luminous patches is supplemented; and, finally, in them we have to deal with the repulsion of the particles, very shortly after they are projected, which is of special importance in the light of the recent evidence that the repulsion may cease to act.

The best defined and most regular envelopes on the Greenwich plates are those of October 27th; the envelopes approach the parabolic form so closely as to confirm our hypothesis as to their formation, and to indicate that any disturbing forces are small. I give below some measures of two of the envelopes shown on that night on plates taken at various times. The first column shows the height of the arch deduced from measures made at the apex, that is to say, by direct measurement; the second column from measures made of the direction of the envelope near the ends of the latus rectum, and therefore deduced indirectly. We have thus two independent determinations of the height.

The accompanying table shows very characteristically the transitory nature of the envelopes and of the explosions. The large one, for instance, formed at about 8 h. 30 m. (it was hardly formed in the first photograph), and in the space of two hours subsided from its original height of 70,000 miles to 40,000 miles; that is the typical behavior of the envelopes; it indicates that the explosion is strongest at first, and

ENVELOPES OF COMET C, 1908 (OCTOBER 27TH).

(Distance of the vertex of the envelope from the nucleus of the comet.)

Time, H. M.	Outer Envelope.		Inner Envelope.	
	(1) Miles.	(2) Miles.	(1) Miles.	(2) Miles.
8 23	71,000	71,000	43,000	35,000
9 3	64,000	61,000	38,000	30,500
9 32	51,000	50,000	26,500	30,000
10 2	48,000	44,000	16,000	14,000
10 28	42,500	41,000	21,000	19,000

(1) Deduced from measurements made at the vertex.
(2) Deduced from measurements of the course of the envelope near the ends of the latus rectum.

then dies down rapidly. But we can make another deduction: the envelope was beginning to form at 8 h. 23 m.; by 9 h. 3 m. the complete arch was visible. Now it can be shown theoretically that the formation of an envelope does not take place instantaneously along the entire arch; if, for example, the material forming the apex left the nucleus an hour previously, that forming the ends of the latus rectum left an hour and twenty-five minutes previously, and so on in proportion. Conversely, we can argue from the fact that the whole arch appeared in so short a time, and that the ends of the latus rectum begin to collapse very little, if at all, after the apex, that the time taken by the matter to travel from the nucleus to the apex must be very small. I dare not trust the figures in the table so far as to calculate that time from them, but probably it will be a very safe outside limit if we say that that time is not more than two hours. A simple calculation shows that, for that to be the case, the solar repulsion acting on these particles must be at least 800 units—far larger than any repulsion calculated by Bredichin, Jaegermann, or others; the velocity of projection would need to be 70,000 miles per hour. These figures are far too startling for us to immediately accept them; though of course if it is admitted that the repulsion acts only for a short time, instead of continuously, it must be correspondingly more powerful during that time. We are at the beginning, not at the end of an investigation; but I am convinced that a great deal is to be learned from the study of these envelopes. Unfortunately they are often very complicated. Sometimes two of them will intersect, or they may be all askew. That need not

be considered surprising, for the simple parabolical form can only occur when the force of the explosion is equal in all directions.

Another feature sometimes possessing some degree of regularity is the waving of the streamers proceeding from the head. This is a feature which will certainly repay a much more careful examination than we have yet had time to give. The most immediately striking feature is that two or more of the streamers often run parallel to one another, their undulations exactly corresponding with the crest of one fitting over the crest of the other. As might be expected, the undulations become larger, both in length and in amplitude, as we proceed outward from the head. Prof. Wolf has published some interesting data on this point. The thought suggests itself that the curves may be spiral curves produced by a rotation of the nucleus of the comet while it is discharging the streamers. The hypothesis is one which can probably be tested by careful measurement; meanwhile it appears to be more probable that the undulations, like so many other features, must be accounted for by changes, perhaps rhythmic changes, in the force of expulsion of the material.

Whatever may be the true cause of the phenomena of comets' tails, it is at least clear that the source of the power which forms them and which directs them is to be found in the sun. I am not sure that the exceptional activity of this comet is not due to the physical state of the sun at the time rather than to the constitution of the object itself. Certainly progress in explaining the phenomena is hampered by our partial ignorance of the electrical and physical conditions of the sun's surface. Therefore I cannot close this discourse without alluding to what is perhaps the greatest result of any that recent years have afforded to astronomy: Prof. Hale's photographs of solar vortices and investigations of their magnetic fields. With the great Tower telescope in the clear atmosphere of Mount Wilson Observatory he obtained photographs of the remarkable structure, revealing to our eyes the gigantic whirlwinds raging over the solar surface above the sun spots. These photographs are taken with the light of one particular wave-length, the H α line of hydrogen. He has gone further and shown, I believe, to the satisfaction of physicists, that the light passing up through these vortices bears the sure marks of having passed through a strong magnetic field, whose lines run perpendicular to the solar surface, and that, according as the vortices rotate clockwise or counter-clockwise, the lines of magnetic force run from or into the sun. The chain of evidence seems to show that the field is produced by the rotation of negatively charged material in these vortices.

It would be hard to exaggerate the value of these latest revelations as to the condition of the sun, far though they are from satisfying our inquiries or enabling us to realize that power which over all the millions of miles convulses the comet and scatters its trailing debris to the remotest parts.

A consular report states that increasing attention is being devoted in German cities to all questions connected with atmospheric conditions. The fact that sunshine lessens as population becomes more dense, and especially when the activity of industrial centers expands superficially and increases in intensity, has long been noted. An increasing tendency to fog has also been observed, and both are effects of the imperfect and incomplete combustion of coal. Modern industry pays toll for this in the injury of delicate fabrics, the general depreciation in the value of many articles of trade and household use, and the increased cost of cleansing. Since the battle is waged with growing energy against tuberculosis, physicians and students of social science feel that the problem of purer air for the dwellers in cities has become one of prime importance. Statistics have been collected for some time past, which demonstrate how little sunshine falls to the lot of the residents of industrial cities, even when the sun is unobscured by smoke particles. In no German city has the loss of sunshine due to fog equaled that of London, where the foggy days during the three months, December, January, and February, increased from eighteen to thirty-one during the last half of the past century.

* Abstracted from a discourse delivered before the Royal Institution.

MODERN FAC-SIMILE TELEGRAPHS.

THE WIRELESS TRANSMISSION OF DIAGRAMS, HANDWRITING, AND PHOTOGRAPHS.

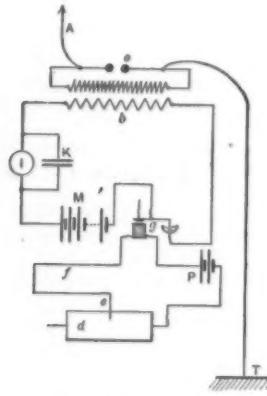
BY DR. ALFRED GRADENWITZ.

A SPANISH engineer, G. J. de Guillén-García, has just presented to the Royal Academy of Barcelona an account of a system for the telegraphic transmission of handwriting or sketches, according to which results may be obtained without the intermediary of any conducting wire, that is to say, by the aid of electromagnetic waves.

It will be remembered that outside of wireless telegraphy proper electromagnetic waves have been recently used for obtaining at a distance various mechanical effects—operating engines, steering balloons or launches, etc. The present invention is an interesting addition to these rather unexpected applications of the principles of wireless telegraphy.

In the transmission of pictures, either through telegraph wires or through the agency of electromagnetic waves, sketches and handwriting on one hand and photographs on the other should be dealt with separately. In both cases García uses two wireless stations of any system, the sender of the transmitting station and the Morse apparatus at the receiving station being replaced by synchronical cylinders, that is to say, by cylinders of equal size and speed of rotation. A style touching the surface of either of the cylinders (which are rotated uniformly by clockwork or the like) will perform a rectilinear motion, thus forming helical lines of uniform path and diameter.

The circuit of a galvanic cell comprises the styles and cylinder of the transmitting apparatus, as well as a relay for opening and closing the current leading



ATTACHMENT FOR TRANSMITTING SKETCHES OR HANDWRITING.

to the coil of the apparatus emitting the electric waves.

The style of the receiving apparatus replaces the style of the Morse apparatus used in ordinary wireless telegraph receiving stations, and like this, traces lines of variable length either black or colored during the time of emission of Hertzian waves, that is to say, traces accurately the same lines as the style of the transmitting station.

Fig. 1 is a diagram of a wireless telegraph transmitting station provided with García's attachment for transmitting sketches and handwriting, and Fig. 3 is a similar view of the apparatus used in transmitting photographs. Fig. 2 shows the receiving station used for receiving sketches or handwriting or photographs. Figs. 4, 5, 6, and 7 are end views of the cylinders c, c', c'', and c''' drawn to a magnified scale.

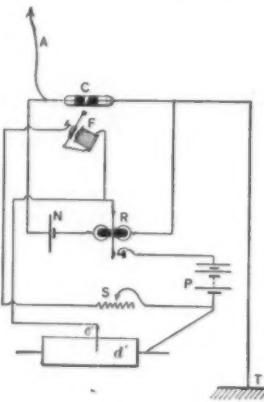
In the transmitting station, according to Figs. 1 and 3, a rotating cylinder d with a style e in contact with the latter is arranged in the circuit f of a source of electricity P comprising a relay g. At the receiving station, according to Fig. 2, a rotating cylinder d' with a style e' is arranged in a similar way, both the cylinder and style moving synchronically with the cylinder and style of the sending station.

The relay (Figs. 1 and 3) is inserted between the style e and the current interrupter of the coil or transformer b, and is so arranged that while the style is traversed by electric current, the relay will close the circuit, when a spark will be produced, resulting in the emission of Hertzian waves.

If now the cylinder, according to Fig. 1, carries a diagram drawn with an insulating ink, the relay, while the metal style e is moving over the metal surface of the cylinder d, will lead no current to the transformer b, and accordingly no sparks and Hertzian waves will be produced at o. As soon, however, as the style e is applied to the drawing, the latter being

non-conductive, the style will not be traversed by any current, and the relay g will accordingly close a circuit comprising the transformer coil b, so as to produce sparks and Hertzian waves.

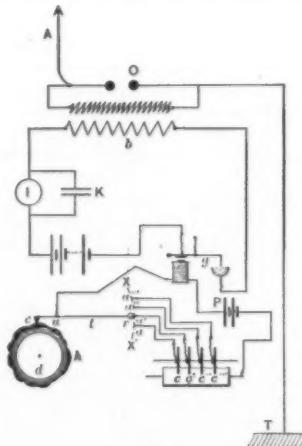
If at the receiving station (Fig. 2) the cylinder d' be coated with paper moistened with some chemical



RECEIVING APPARATUS FOR EITHER SKETCHES OR PHOTOGRAPHS.

solution, such as potassium ferrocyanide or ammonium nitrate, the pointed style, owing to the Hertzian waves issuing from the antenna t, will trace on the paper a line of variable length (according to the duration of the Hertzian waves or the time during which the transformer circuit is closed by the relay g of the sending station) each time the style e' is traversed by the current of the coil b. As the styles of both stations are performing equivalent motions of equal length, the lines traced by the style e' will be equivalent to those drawn by the style e on its passage over the diagram. The two styles e and e' thus describe on their cylinders accurately equivalent spiral lines, the path of which is smaller than $\frac{1}{2}$ millimeter, and the diagram of the cylinder d will be accurately rendered on the paper coating of the cylinder d'.

The cylinders d and d' may be replaced by movable or stationary metal disks, and the motion of the styles e and e' may be designed for describing identical paths on the corresponding disks. There can further be used two synchronical apparatus, in which the styles are performing spiral lines similar to those of gramophone disks, or any similar apparatus performing synchronical motions, so that the style e' will render partly or integrally the sketch carried by the cylinder or disk d. The original diagram should be



ATTACHMENT FOR TRANSMITTING PHOTOGRAPHS.

produced on a metal foil of tin, aluminium or the like, and the foil applied to the cylinder. In the place of the chemically active styles e and e', a style or roller can be used, which on the passage of a current, will trace a line.

If now on the cylinder d' there be placed a diagram to a magnified or reduced scale, all that is necessary is to replace one of the two cylinders by a cylinder of corresponding diameter, taking care that both cylinders should perform accurately the same number of rotations.

In transmitting photographs, the apparatus of the receiving station, according to Fig. 2, is not altered, whereas the sending station should be altered according to Fig. 3.

The cylinder or metal disk d is provided with a positive or negative relief h of bichromated gelatine or some other substance. The style e is fitted to the end of the double lever t, which on the rotation of the cylinder d will go up and down, corresponding to the relief at the cylinder surface. The axis u of this double lever t is connected with one of the terminals of the cell P. At the end of the lever there is attached a roller r for producing a contact between the lever t and the insulated metal pieces a, a', a'', a''' and the non-metallic contacts x and x'. All these contact pieces are placed in the circular trajectory of the roller r. Each of the insulated metal contacts a, a', a'', a''' is connected by wire with one of the disks, c, c', c'', c''', which are mounted in common on a shaft of ebonite or some other insulating material rotating at a uniform speed. One of these disks c has a smooth edge, while the others are provided with circumferential teeth or projections, which while being uniform in a given disk will vary from one disk to another. All these disks are in contact with a metal cylinder connected by the conductor f to the cell.

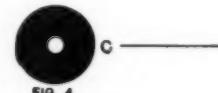


FIG. 4



FIG. 5



FIG. 6

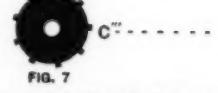


FIG. 7

THE CYLINDERS USED IN TRANSMITTING PHOTOGRAPHS.

According as a positive or negative relief is used, the white portions will correspond to deep or elevated portions of the relief, so that the roller r will come in contact with x or x' on this portion being traversed by the point of the style, no current being transmitted and no lines being produced at the receiving station.

As the style e is lifted or lowered, the roller r at the end of the lever t will be likewise raised or lowered, so that the current traversing the roller will pass one or other of the disks c, c', c'', c''', thus reducing or augmenting the intensity of the current and accordingly the emission of Hertzian waves, according to the profile of the edge of the disk.

The style of the receiving station on the impulse of the electric waves will trace full lines by the aid of the disk c having a smooth edge. These lines will correspond to the black portion of the diagram, whereas the disks c, c', c'', c''' provided at the edge with teeth or projections will result in the production of non-continuous lines according to the different shades of the diagram.

The practical results obtained by this process will soon be made public.

Most portions of Asia Minor are believed to be rich in mineral deposits. Some few mines have been worked and proved to be highly remunerative, but most of the mineral wealth of the country remains undeveloped. According to a recent American report, the consular district of Trebizond, which embraces the northeast quarter of Asia Minor, has been only superficially explored, although many outcroppings of minerals have been found, and there are many places where, at some remote period, the ancient inhabitants of this region, or the Greeks and Romans, extracted ore. Their instruments were rude and their methods primitive. They rarely went far below the surface. They left around their primitive diggings quantities of ore which with modern methods of extraction would be considered worth working. Copper, iron, manganese, gold, silver, mercury, zinc, antimony, arsenic, coal, and petroleum are known to exist in this district, but to what extent remains to be seen.

THE WONDERFUL GYROSTAT.*

ITS PRINCIPLES AND APPLICATIONS.

BY HORACE B. M'CABE.

THE gyroscope is an old and familiar toy which has always been a source of speculation. The peculiar actions of the rapidly rotating wheel are seldom correctly explained and a wrong impression exists generally regarding the nature of these actions. Renewed interest has been taken in the device within the past two years on account of two very interesting successful

of a flat spring which may be adjusted to tension against the brake disk on N by the thrust knob shown. The locking means is shown at C and consists of a set screw b which may be brought to bear against the disk on N , thus locking it in any position desired. The normal position is as shown with the rings perpendicular to each other, although it is not necessary

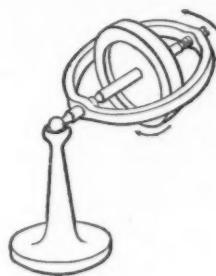


FIG. 1.

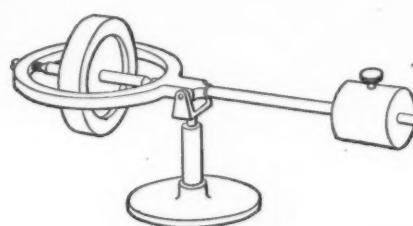


FIG. 2.

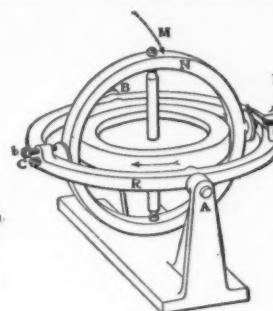


FIG. 3.

DIAGRAMS ILLUSTRATING THE GYROSCOPE.

applications to practical uses, by Dr. Schlick and by Mr. Brennan.

As the name "gyroscope" is more suggestive of the toy I will hereinafter use "gyrostat" instead, as that seems better adapted for the practical machine.

Dr. Schlick has mounted a large, steam-driven gyrostat in the hold of a 200-foot torpedo boat to prevent rolling in rough water. Mr. Brennan has built a locomotive that will run on a single rail and maintain its equilibrium above it by using two motor-driven gyrostats. So far, however, no extended use of the devices has developed.†

As the matter is of interest and as many erroneous impressions exist in regard to the nature of the action of the gyrostat, the following is written with the hope that it will correct these impressions and set forth something substantial in the way of rules which may be of use to the engineer in the design of new applications of the device.

As we are no doubt all aware, the gyrostat in its elemental form is simply a flywheel provided with means for giving it rapid rotation, and mounted in such a way that its axis can tip in any direction. The most familiar form is shown in Fig. 1, which shows the common toy gyroscope. Fig. 2 shows the same form but provided with a counterweight and intended for laboratory use. By this form of the device it can be demonstrated that when the weight of the wheel and frame overbalances the counterweight the whole thing will revolve on the standard in the same direction as that of the underside of the wheel. When the counterweight is adjusted to overbalance the wheel and its frame the movement about the standard will be in the opposite direction.

DESCRIPTION OF MECHANISM AND ACTIONS OF GYROSTAT.

These forms, however, are not best adapted to the intelligent study of the action. We obtain correct con-

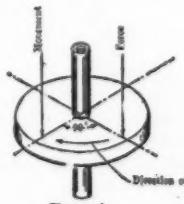


FIG. 4.

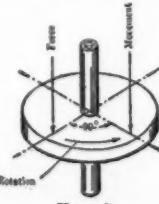


FIG. 5.

DIAGRAMS OF FORMS AND MOTIONS OF GYROSTAT WHEEL.

ceptions more easily when we imagine the rotating wheel floating in space as in Figs. 4 and 5. The way of mounting that most nearly approaches this condition is shown in Fig. 3 in which the wheel is mounted in the gimbal rings N and R . The out ring R is made to swing on trunnions in bearings at A and B in a stationary base and the inner one N is pivoted transversely in R at C and D . There should be a brake provided to damp the swinging movement of the ring N on its axis $C D$ and also a means for locking it rigidly from movement. The brake is shown at D and consists

that the ring R lie in a horizontal plane. The wheel may be given its rotation in the usual way by winding a string on the shaft.

When the wheel is thus put into rapid rotation the following phenomena may be observed: When the

dueing it and depends on the direction of rotation of the wheel. It will be found that if the direction of rotation is clockwise, as shown by the arrow on the wheel, and the pressure is applied as shown by the arrow P the wheel will tip as shown by the arrow M . This being true one would naturally expect to find that a pressure on the ring N resisting the movement M would resist the pressure at P . The natural assumption might be that if the pressure will cause a movement, a resistance to that movement should act as a resistance to the pressure causing it. But in this case the contrary will be found to be true and the pressure applied on the ring N in the direction opposite to the arrow M will cause the end D to move down in the direction of P .

GENERAL RULES GOVERNING GYROSTAT ACTION.

Following are given a few general rules deduced from the experiments. In connection with these rules, Figs. 4 and 5 are given in which the wheel is viewed abstractly as if floating in the air and rotating at a high speed. In each figure the direction of rotation is shown by the curved arrow. The force is assumed to be applied near the periphery and in a direction always normal to the plane of the wheel as the arrow indicates. A jet of compressed air impinging on the side of the rim would exemplify this. The movement resulting from the force is also represented by an arrow in a similar position. This arrow merely represents the direction in which the side of the wheel will start to tip or swing about its center when the jet of air is applied and is tangent to the actual direc-

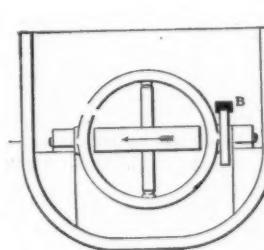


FIG. 6.

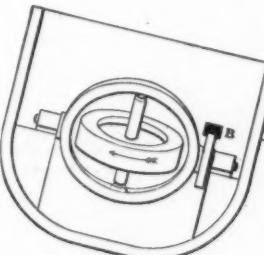


FIG. 7.

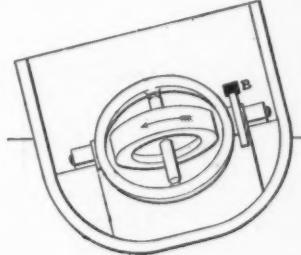


FIG. 8.

DIAGRAMS OF DR. SCHLICK'S APPLICATION OF GYROSTAT TO A TORPEDO BOAT.

finger is pressed on the ring R at D the wheel will tip on the axis $C D$ in one direction while if the pressure of the finger is transferred to C it will tip in the opposite direction. While the wheel is tipping a decided resistance to the pressure will be felt. If the pressure is increased the tipping will be more rapid and the downward movement of the finger much less, due to a greater resistance which can be felt.

If a strong pressure is applied, the wheel will tip very rapidly around to a horizontal axial position while no perceptible downward movement of the finger will be noticed. But, however, as soon as the axis does reach the horizontal position all the resistance ceases and the sensation will be as if a rigid support had been underneath and was suddenly removed. If the ring R is struck a forcible blow at C or D with the fingers the sensation will be much like striking a very stiff spring. No permanent downward movement will occur, but the wheel will tip some and remain so.

If the experiments are performed with the brake spring brought up to tension the tipping action of the wheel will be slower and at the same time less resistance to the pressure will be felt and the finger will go down more rapidly. If the binding screw is set so that no tipping of the wheel on the axis $C D$ can occur no resistance to the pressure will be felt and the finger will go down as easily as if the wheel were not rotating.

As would be expected, if instead of applying the pressure to the ring R it is applied to the ring N in a way tending to swing it on the axis $C D$ there will occur a tipping movement of the wheel and likewise ring R on its axis $A B$.

In the experiments one thing is strikingly evident, that a tipping movement of the wheel through a large angle is not necessarily attended by any extensive movement in the direction of the pressure at the point where it is applied, and, indeed, if the pressure is quite strong and the brake spring entirely free, there will be no perceptible movement at the pressure point, while the wheel is tipping, and the stronger the pressure the less will be that movement.

In all cases the direction of the tipping movement is at right angles to the direction of the pressure pro-

tion of the movement at that point. The above being made clear, here are the rules:

1. The force arrow and the movement arrow are in planes normal to the plane of the wheel and always at right angles with each other.
2. The movement

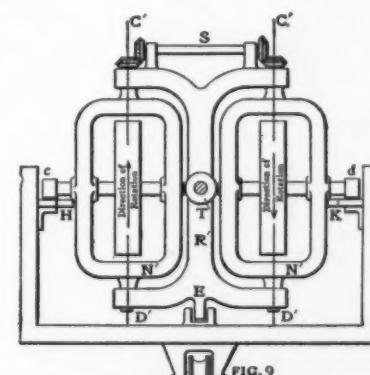
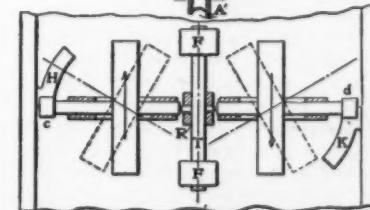


FIG. 9.



FIGS. 9 AND 10.—DIAGRAMS OF BRENNAN'S APPLICATION OF THE GYROSTAT TO A SMALL LOCOMOTIVE.

arrow, when considered ahead of the force arrow with regard to the direction of rotation, will have the same direction as the force arrow. In other words the force and the movement are in the same direction when the latter is considered at a point 90 degrees ahead of the former.

3. All the movement will occur

* American Machinist.

† In his article in *Nature*, March 12th, 1908, Prof. John Perry goes deeply into the theory of the action of these devices of Dr. Schlick and Mr. Brennan.

at the movement arrow and none at the force arrow. 4. As long as the movement can freely take place at the movement arrow the force at the force arrow will be opposed by an equal force. 5. Any damping effect on the movement to retard it will cause the movement to be slower and a consequent movement will occur at the force arrow in the direction of the force. 6. If the wheel be completely restrained from its movement at the movement arrow, all the movement will occur at the force arrow and no resistance whatever will oppose the force. 7. The velocity of the movement will depend on the magnitude of the force. An increase in the force will produce an increased velocity of movement.

Rule 5 will be verified when it is considered that the damping effect must be produced by a force opposing the movement and by Rule 2 this will cause another movement in the same direction as this opposing force and at a point diametrically opposite the force arrow and thereby lessen the opposing resistance at the force arrow.

Referring back to Fig. 1 it may now be plain that the force causing the movement about the standard is the weight of the wheel and ring. If the wheel speed could be kept constant and there were no friction at the swivel point on top of the standard the wheel and ring would revolve around it in strict accordance with Rule 1 and it would maintain its axial angle in accordance with Rules 3 and 4.

The fact that the wheel will gradually sink, however, even though the rotative speed be constant, is in accordance with Rule 5, the friction on the standard being the damping effect.

Referring to Fig. 2 in which the direction and amount of the force may be adjusted by the counter-weight, the direction of the movement about the standard will be in accordance with Rule 2 and the variation in the velocity of the movement will be in accordance with Rule 7. Rule 6 may be strikingly verified by placing some rigid obstruction in the path of the weighted arm.

A top with a sharp point spun on a wood table where it may find a stationary rotation center will behave exactly like the wheel in Fig. 1. It is a familiar sight to see a skillful bicycle rider round a corner at high speed without touching the handle bars. He does this by simply leaning inwardly, which causes his front wheel (which is a gyrostat) to swing in accordance with Rules 1 and 2. A rolling hoop will not fall, because as soon as it begins to tip to one side or the other it will, in accordance with Rules 1 and 2, begin to turn in the direction of the tipping, which will bring the lower part of the rim again under its center of gravity. Looking at it from another point of view, the hoop being free to swing in either direction at right angles to the force which acts to tip it this force will be resisted by an equal opposing force and, according to Rule 4, no tipping can occur.

DR. SCHLICK'S APPLICATION OF THE GYROSTAT.

The principle of Dr. Schlick's application of the gyrostat to a ship is shown in Figs. 6, 7 and 8, which represent diagrammatically the gyrostat in the hold of a ship, the means of rotation not being shown. At B is a brake which it is assumed has some means of adjustment for tension, so that any desired damping effect on the tipping action of the wheel may be procured. Suppose the wheel maintains a high rotative speed in the direction of the arrow. If the position of the wheel when the boat is normal is as in Fig. 6, it will, when the boat rolls, tip as shown in Figs. 7 and 8, and offer a great resistance to the rolling action. Rules 3 and 4 will indicate that it is not necessary that the boat actually roll any perceptible amount in order to make the wheel tip through a large angle, and in point of fact, it is reported that the boat may be standing apparently still and upright while at the same time the wheel is tipping violently back and forth.

The office of the brake is merely to prolong the tipping action to suit the period of oscillation of the boat. According to Rule 4 it is evident that if the brake is set tight so that the wheel cannot tip, no resistance to the rolling will exist. It may be reasoned, however, that according to Rule 1 the rolling action in this case will have a tendency to cause the boat to pitch, while any pitching of the boat will have a tendency to cause it to roll.

MR. BRENNAN'S APPLICATION OF THE GYROSTAT.

The application of the gyrostat to the monorail car by Mr. Brennan is shown diagrammatically in Figs. 9 and 10. Two gyrostats are used and made to run in opposite directions, so that there will be no ill effect on the car in rounding curves. They are constrained to swing in unison by means of the bevel gears and shaft at S. The elemental parts of the machine may be seen to correspond with those in Fig. 3. The frame R' corresponds to the ring R, and the rings N' to the ring N. The axis A'B' corresponds to A B, and passes through the shaft T, which supports the frame R', and is mounted on bearings F rigid with the car. The rings N' swing on the axis C'D', which corresponds to the axis C D. The frame

R' has a lug E at its lower end embraced by a fork made fast to the car, which allows the frame R' a very small amount of swing. The wheel shafts have at their outer ends the friction wheels c and d. Underneath these and extending in the directions shown in Fig. 10 are the runways H and K, which are fastened rigidly to the car.

If the car starts to tip to the right both wheels will, according to Rule 2, swing toward the position shown by the dotted lines, Fig. 10, and at the same time the runway H will move up to contact with the friction wheel c which will try to roll forward thereon. The pressure on the wheel axis caused by this effort to roll forward is in a direction to cause a movement of the car to the left. When this begins to occur the runway H will lower from c, and there being no runway under d in this position of the wheels the fork will engage the lug E, and as the movement to the left still continues the wheel will in accordance with Rule 2 swing back into axial line again. Continued movement of the car to the left will cause the reverse of the above sequence of actions, and the runway K will move up to engage the friction wheel d.

The movements of the wheels will not be to the extent shown by the dotted lines, and the tipping of the car under normal conditions will be unnoticeable. This is the most interesting and wonderful of all applications of the gyrostat.

When standing still the center of gravity of the car will adjust itself always exactly over the rail. The weight of a passenger placed on one side of the car will cause that side to go up. A pressure such as the wind against one side will cause the car to lean to that side until the pressure is just balanced. In rounding a curve the car will lean inward just the correct amount.

ENGINEERING NOTES.

A 400-horse-power vertical water-tube boiler of the type having water and steam drums connected by the water tubes, exploded in the Denver Gas and Electric Co.'s power plant in Denver, Col., last June. The bottom head of the lower drum ruptured at the rivet holes where connected to the shell, and the boiler "sky-rocketed" to a calculated height of over 1,600 feet; it fell into the engine room 175 feet from its starting point and demolished a Hamilton-Corliss engine and two large direct-connected generators. The explosion caused the immediate death of four persons and serious injuries to four others. The estimate of the damage to property ranged from \$60,000 to \$200,000. The explosion and calculations of the height to which the boiler projected itself were the subjects of an interesting article in the Locomotive.

It has been decided, after an experiment extending over two years in the Place de la République, one of the busiest squares in Paris, to adopt the method for the laying of wood pavement which has been thus tested, along the entire length of the Rue de Rivoli. The process in question, which is the invention of M. Managnan, consists in a preliminary treatment of the wood blocks to give them the qualities of suppleness and strength. The wood is heated to a temperature of 80 deg. C. in a special bath, containing alkali, carbonates, and wood tar. By this treatment it loses 20 per cent of water and 10 per cent of solid matters of various kinds, and there remains a timber, the density of which has been increased by 40 or 50 per cent. The new material prepared in this way avoids the necessity of repairs for two years at least, which, in Paris, entail a cost of not less than 30 cents per square meter annually.

At last, states a consular report, the celebrated circular railway round Moscow, which has been in construction for so many years, and has cost so many millions of rubles, has been completed and opened. The results, however, have been anything but satisfactory. First, as regards passenger traffic, owing to the high fares and even more owing to the stations being often built in the middle of fields without any means of getting to them, the line has proved a complete failure. The number of passengers was absolutely ridiculous, a few dozen per month, and in the autumn it was decided to suspend passenger traffic. Affairs are but little better as concerns goods traffic. Owing to the exceptionally high and unsatisfactory tariff, every merchant who can possibly manage it avoids using the line for transporting his wares. In a word, the line has in no way fulfilled the expectations of the government, which financed the undertaking. Seeing that affairs are in a hopeless state, the government are going to revise the tariff, when possibly the line may begin to exercise the influence hoped for by the constructors.

His Majesty's Legation in Brazil reports that at the end of the year 1908 that country possessed 18,628 kilometers (about 11,570 miles) of railway open. Over 8,000 kilometers (nearly 5,000 miles) of this extent of line are the property of the Federal government. 4,000 kilometers have been constructed under the terms of various concessions generally for sixty years,

and will eventually revert to the Federal government, while the remaining 6,000 kilometers represent railways owned by the States of the Union. Over 1,000 kilometers of line were opened to traffic in 1908, a record in Brazil. Most of the larger systems have been formed by the amalgamation of a number of smaller lines, and include varieties of ownership and tenure. The large systems tend to increase and become important corporations; they are, as a rule, centered in one State—the Federal government having only lately introduced a constructive policy of interconnections—and they follow each other along the Atlantic coast from north to south, the lines running roughly east and west and converging at a particular port. Railway administration and construction are in the hands of the Federal Ministry of Communications and Public Works.

SCIENCE NOTES.

Specialization in schools often prevents students of science from acquiring sufficient knowledge of mathematics; it is true that most of those who study physics do some mathematics, but in general they do not do enough, and they are not as efficient physicists as they would be if they had a wider knowledge of that subject. There seems at present a tendency in some quarters to discourage the use of mathematics in physics; indeed, one might infer, from the statements of some writers in quasi-scientific journals, that ignorance of mathematics is almost a virtue. If this is so, then surely of all the virtues this is the easiest and most prevalent.

A German scientist, E. Kolber, has brought out some points about the effect of silicon on the magnetic properties of iron, and the question is one of great interest from a practical standpoint, because iron containing various proportions of silicon is now manufactured on a commercial scale. He finds that the electrical resistance of silicon iron is much higher than for ordinary iron, while the magnetic properties are not lessened, so that we have here a higher resistance for Foucault currents and the latter are accordingly lessened. The specific resistance of an iron having 3½ per cent of silicon appears to be five times that of ordinary sheet iron, so that we should find the eddy currents so much less. He uses samples of iron with the silicon ranging from 0.026 to 3.52 per cent. Taking the iron loss in watts per kilogramme with the specimens he finds that it is from 3.8 to 1.5 watts in favor of the silicon iron. According to this, we should be able to reduce iron losses by two-thirds, at least in many cases. This is especially true in the case of transformers, while on the contrary the silicon iron is less elastic from a mechanical standpoint and is not well adapted for revolving parts of generators. For transformers there could be obtained a much better design owing to the smaller iron losses which are used as a basis, and the silicon iron has a very good permeability value.

The water bottle for getting water for analysis from selected depths in the ocean is a cylinder of brass, German silver, or other metal which resists the corrosion of sea water, generally about 2 inches in diameter and 12 or 14 inches long, with upward-opening valves at the top and bottom, connected together on a central stem. Lugs are cast on the side of the cylinder for conveniently securing it at any point along the length of the line by which it is to be lowered into the sea. During the lowering of the line the valves of the bottle are kept unseated by the passage of the water through the cylinder during its descent; but, when the motion is reversed, the valves seat themselves and are locked by the descent of a small propeller in the framework above the upper valve, which rides idly on a sleeve during the lowering of the bottle, but descends along a screw thread to press the valves upon their seats when the line commences to be hauled up. A specimen of the water at the depth to which the water bottle has descended is thus brought to the surface confined within the bottle, and a series of specimens from different depths may be obtained at one haul by securing a series of water bottles at the required intervals along the sounding line.

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